United States
Environmental Protection
Agency

Solid Waste And
Emergency Response
(OS-240)

EPA/540/8-91/012
May 1991

EPA

Design And Construction Issues At Hazardous Waste Sites

Conference Proceedings

Part 1: Pages 1 thru 700

Hyatt Regency at Reunion
Dallas, Texas
May 1 - 3, 1991

EPA/540/8-91/012
OSWER DIRECTIVE #9355.8-01
MAY 1991

Design And Construction Issues At Hazardous Wastes Sites

CONFERENCE PROCEEDINGS

HYATT REGENCY AT REUNION, DALLAS, TEXAS
MAY 1-3, 1991

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Emergency and Remedial Response
Harzardous Site Control Division
Washington, D.C. 20460

Printed on Recycled Paper

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ACKNOWLEDGEMENT

The U.S. Environmental Protection Agency (EPA) wishes to thank all of those who participated in the development of the Agenda, Proceedings Manual, and attended the first "Conference on Design and Construction Issues at Hazardous Waste Sites", held between May 1-3, 1991 at the Downtown Hyatt Regency at Reunion in Dallas Texas. The feedback received during and after the conference was extremely positive; it is EPA's plan to sponsor this conference on an annual or biennial basis over the next several years until a 'steady-state' in design and construction at hazardous waste sites is reached.

Several individuals played an important role in making the conference the success it was. In particular, Kenneth Ayers, William Zobel, and Edward Hanlon of USEPA, and Michael Blackmon and Chris Fafard of PEER Consultants, and the PEER Consultants Word Processing staff, should be recognized. We thank these individuals, the Conference Abstract Review Committee, and the authors, speakers, panel members, and conference participants for a job well done. Their efforts will help insure that design and construction efforts during hazardous waste site remediation will continue to see quality improvements in future years.

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PREFACE

CONFERENCE ON DESIGN AND CONSTRUCTION ISSUES AT HAZARDOUS WASTE SITES MAY 1-3, 1991, HYATT REGENCY AT REUNION, DALLAS

The first U.S. Environmental Protection Agency (EPA)-sponsored national conference on design and construction issues at hazardous waste sites occurred between May 1-3, 1991 at the Downtown Hyatt Regency at Reunion in Dallas Texas. Ninety-five presentations of technical papers with three panel discussions on technical/policy issues and case studies were held.

Included in this publication are questions and answers from the panel discussions, as well as text of the technical papers. In some cases, the authors' names and addresses are included at the end of their respective papers. This 'Conference Proceedings' culminates and memorializes the significant efforts made at and for this conference.

This national conference was warranted and timely due to the increased complexity of issues related to this subject area and the growing number of hazardous waste sites entering design and construction. The conference also had a different intent, agenda and format than other major hazardous waste conferences. An open exchange of ideas to promote formal and informal discussion of design and construction issues was planned, in order to encourage national consistency, help develop more efficient and practical means to move design and construction projects through the pipeline, and augment EPA's current efforts to revise its Superfund design and construction guidance and policies.

Topics covered a range of issues, including pre-design activities, construction administration and claims, community relations, health and safety, and government policy. Participants include the U.S. Department of Energy (DOE), Department of Defense (DOD), Bureau of Reclamation, and Army Corps of Engineers, as well as EPA, numerous design and construction contractors and State agencies.

EPA wishes to thank all of those who participated in the first "Conference on Design and Construction Issues at Hazardous Waste Sites". It is EPA's plan to sponsor this conference on a regular basis over the next several years. The next conference is tentatively planned for early April, 1992 in Chicago.

Future inquiries regarding this conference and next year's planned conference are encouraged to be made in writing to the attention of: Kenneth Ayers, Chief, Design and Construction Management Branch, U.S. Environmental Protection Agency, 401 M Street, SW, Mailcode OS-220W, Washington DC 20460, or by contacting EPA's Design and Construction Management Branch at (703) 308-8393.

SUMMARY OF QUESTIONS AND RESPONSES FROM THE PANEL SESSIONS

DESIGN AND CONSTRUCTION POLICY PANEL SESSION

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USEPA

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USACE

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Texas Water Commission

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U.S. Department of Energy

John J. Smith
Acting Branch Chief
Remedial Operations and Guidance Branch
USEPA

James Moore
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1. **QUESTION:** What support is available through the Corps of Engineers or the Bureau of Reclamation for RCRA-lead actions?

   RESPONSE: The Corps and Bureau of Reclamation are available and have done support of RCRA actions.

2. **QUESTION:** How are lessons learned at remediation sites in Texas shared?

   RESPONSE: Papers are presented at Conferences such as this. The State is open to provide any information they have to interested parties.

3. **QUESTION:** With regard to Texas State Enforcement actions, how do you view cost recovery and what documentation is acceptable with the courts?

RESPONSE: Cost recovery on non-NPL sites has been successful on solid waste enforcement sites. On NPL sites the recovery is conducted in conjunction with the EPA. The State Superfund program has not proceeded far enough to start recovery.

4. **QUESTION:** With the new shift to PRP lead RD/RAs, we need to evaluate what the PRPs are like; some may be trusted, some not. This may be determined in the negotiation process. It should be considered that the public does not trust the PRPs.

RESPONSE: A draft PRP Oversight Guidance Document has been prepared and distributed to RPMs. Current EPA staffing and funding will not be able to handle oversight of a large number of new sites. The amount of liability that the EPA will assume in PRP oversight must be evaluated. Possibly each enforcement action needs to be evaluated, case by case, and as little oversight as necessary be used. Begin with high oversight and, if the PRP is determined to be performing acceptably, reduce the amount of oversight. This approach is presented in the guidance which is still out in draft form, awaiting feedback. The guidance is flexible, based on the RPM's evaluation of the PRP performance. Part of the guidance was to have the PRP provide an Independent Quality Assurance Team provide QA data to the RPM for review. This point is still in contention.

5. **QUESTION:** When can we expect an agreement between EPA, Corps and Bureau of Rec on data validation?

RESPONSE: EPA Region 2 does have an agreement with the Corps, and a national agreement has been proposed. Current trends are shifting toward more autonomy to the EPA Regions, and fewer national agreements are being signed. EPA Regions and the respective Corps and Bureau of Reclamation representatives need to determine, on a Region-specific basis, whether such agreements are necessary. If so, meetings should be set, and decisions made, on this issue.

6. **QUESTION:** What is the status of "Lessons Learned"? What is the direction for distribution?

RESPONSE: A computerized "Lessons Learned" system was developed at the Corps which every field office could input to and be read at headquarters. The

current status of the system was not available. It is not currently being used for the Superfund Program, but it will be adopted.

7. **QUESTION:** One of the problems many RPMs run into is the acquisition of property during a Remedial Action. Many Remedial Actions have been halted to allow time to acquire a piece of property, property easement or long-term lease. Under SARA, the law requires that any property acquisition during a Remedial Action must be accepted by the State after the action is complete.

In Pennsylvania, the Commonwealth has refused to accept any of the acquired properties. Since an agreement with the Commonwealth has to be in place prior to the property acquisition, projects in Pennsylvania are stifled at the time. Is anything being done to deal with the States' concerns that they will be liable for any contamination remaining on the site after the Remedial Action?

RESPONSE: It is a requirement under the law; we can't get around this. EPA's tentative understanding is that states may not be considered liable for any contamination remaining on the site after remedial action. However, if only an easement is needed which will expire at the end of the Remedial Action, State approval is not required. If we are buying property and the lease actually comes to the EPA, an agreement for transfer to the State is required. In regard to the liability issue, in the Superfund contract the States have agreed to operate and maintain long-term remediation after the EPA completes its efforts. We don't understand or know all the details of why Pennsylvania has taken this stand at the this time.

8. **QUESTION:** The States are mainly fearful of "owner liability" for property which they must take over after the Remedial Actions. Is there any effort at Headquarters to relieve the States of this potential liability in the future?

RESPONSE: As discussed above, EPA's tentative understanding is that states may not be considered liable for any contamination remaining on the site after remedial action. EPA is still investigating this issue. However, it was never fully understood why Pennsylvania was not willing to accept the property

acquisitions. This can be discussed with Headquarters Council to see if there is some wording which may assist in the negotiations with Pennsylvania.

9. **QUESTION:** Do you think the Federal Government could be a central data-gathering point for "Lessons Learned" within the Corps, and States as well, and could there be a publication of this data for those who need this information?

RESPONSE: This would be the optimum; however, resources are not available at this time to facilitate this large an effort. For a computer database of "Lessons Learned", significant screening of the data to be input must be done. "Lessons Learned" may become purely emotional or personal, which are not the intent of this type of database. Information which is not clearly worded and analyzed could be misinterpreted or lead to liability. This will require mature screening.

RESPONSE: The EPA Design and Construction Management Branch produces a bimonthly flyer, "RD/RA Update", which provides current information and "lessons learned" on RD/RAs.

10. **QUESTION:** In regard to setting design parameters, I understand that there is a lack of data available to make site decisions. When you get into the construction phase, you need to take the opportunity to seek the data to verify the design parameters that you have designed with and make necessary adjustments. Is the Corps of Engineers putting into place any mechanism to keep the Designer involved during construction to verify design parameters?

RESPONSE: Absolutely. An agreement is made with the designer for involvement throughout construction to discuss problems, etc.

11. **QUESTION:** In regard to AE liability, could this point be expanded on?

RESPONSE: In just the last few years the EPA has gotten heavily involved in design, and we are now seeing designs being implemented. EPA's REM contracts had the standard AE liability clause, which states that if there is an error or omission that the AE firm

will go back and correct this error or omission at no cost, and if the error or omission was caused by negligence and the error caused significant increased costs the AE firm will be liable for these costs (rough interpretation). If the EPA gives the designer definitive direction, more than likely the EPA is assuming liability for the affects of that direction.

The guidance given to the AE determines if the AE is liable for errors. An AE liability clause is being drafted specifically for the ARCs contracts. However, the negligence standard, Section 119 set up for indemnification, may conflict with the liability clause; it is not a clear-cut issue.

12. **QUESTION:** What are the differences between the two liability clauses?

RESPONSE: Section 119 imdemnification addresses third party liability associated with releases or threatened releases. AE liability is two party, which focuses on design errors or omissions. The clause being drafted for the ARCs contracts is not substantially different. It clarifies that for a cost reimbursement contract, if an error or omission occurs the EPA is only asking for the error or omission to be corrected at no cost; EPA is not asking for additional design work to be performed gratis. Also, it clarifies negligence portions so there is not a conflict with the negligence standard, Section 119.

13. **QUESTION:** What efforts have been made by the Corps of Engineers to involve small, disadvantaged or women-owned business in your contracts?

RESPONSE: Efforts are being made to track small and disadvantaged business (SDB) contracts and insure the set-aside levels are met. Future effort will be made to track the amount of subcontracts which are awarded to SDBs.

14. **QUESTION:** Should private industry be performing site clean-up with the question of clean-up sufficiency? Could other mechanisms be used to achieve clean-up? Could the property be given to the AE firm in return for the clean-up? The EPA providing funds to the Corps who then pays an AE does not seem efficient.

RESPONSE: An "orphan" site is a site which does not have a viable PRP. This does not necessarily mean there is not an owner; it means that the PRP does not have the funds or ability to do the remediation. The EPA cannot just take possession of the property. The legal ramifications would be extensive.

In regard to efficiency, the decision was made to get the most technically qualified people working on Superfund site remediations due to the potential risks posed at these sites. Costs were not the central factor. The Corps was determined to have the technically qualified personnel needed. Efficiency, strictly in regard to profit margin, is not the whole picture.

15. **QUESTION:** In Navy programs there is not enough contract oversight available. The oversight official cannot keep up with the amount of data and information generated by several contractors at several sites. The contractors then operate with minimal oversight. I think the Government or the EPA's time would be better spent on enforcement.

RESPONSE: That is one of the problems focused on by EPA Administrator William Reilly - enforcement first; however, resolving this problem will not occur overnight.

The EPA has had a preponderance of excellent contractors and encourages initiative by contractors. It depends on your outlook and how you want to use a contractor. Overall the products received by the EPA have been excellent. However, the EPA would prefer to have 100% enforcement actions and not spend any of the Superfund.

16. **QUESTION:** Any lessons learned from Value Engineering Studies?

RESPONSE: We are very receptive to contractors proposals on how to better clean up sites. At the Sikes project, a major revision is underway. Under State law, however, we cannot share the savings.

There is a Federal value engineering clause in which savings achieved through a value engineering study are shared with the contractor. The Bridgeport, New Jersey site had a value engineering

proposal which was accepted by the government during construction.

17. **QUESTION:** I understand there is an interagency agreement between the EPA and the Corps that states any contract that is more than $5 million will go to the Corps. I recommend that this limitation be extended from $5 million to $10 million. There are 45 ARCs contractors, and you will achieve your goals more quickly and efficiently.

RESPONSE: There is no dollar value specified in the interagency agreement. It was strictly a policy call on EPA's part. Any projected remedial action of less than $5 million, the Regions have their choice of using the Corps, bureau of Rec or an ARCs contractor for either or both Design and Construction. For contracts between $5 million and $15 million, the Regions haves the choice of using an ARCs contractor or Corps of Engineers for design and implementing the construction through the Corps or Bureau of Rec. Anything over $15 million is to be designed and constructed by the Corps of Engineers or Bureau of Rec.

A policy letter has been drafted to consider exceptions to this policy on a case-by-case basis. The Regions would have to make a strong argument to waive this criteria.

COMMUNITY RELATIONS PANEL SESSION

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Community Relations Coordinator
USEPA, Region VI

George Hanley, USACE

Pat Ferrebee
U.S. Navy

1. **QUESTION:** Regarding your comments about not responding argument by argument in the Responsiveness Summary, how do we have a complete Responsiveness Summary if we have, say, forty arguments in the formal comments and do not address them individually?

   RESPONSE: There are situations where the arguments get so outside of the reality of the project that they start creating problems that do not exist, be it a hypothetical question or whatever. Instead of being in a response mode where we literally go through the arguments and respond sentence by sentence, we got back to the basics of "did we consider reduction of volume, toxicity and mobility". We focused on those issues that they were trying to attack, rather than getting into a point by point discussion in the response.

2. **QUESTION:** My understanding of the Responsiveness Summary is that you can take the comments and group them into general points, as opposed to addressing specifics to the letter.

ANSWER: Correct.

3. **QUESTION:** Concerning sending documents out to the TAG group (Technical Assistant Grant group of the New Bedford Community Environmental Awareness Group), they were sent out as draft documents -- were they EPA internally reviewed, or what do you mean by "draft"? Were they documents that actually came from the RI consultant?

RESPONSE: The documents the TAG group received from their own consultant were final documents; the group had hired this consultant to generate their documents. The TAG group received from EPA draft RI documents prepared by EPA's RI consultant.

4. **QUESTION:** I assumed that EPA had a consultant doing the RI/FS; did the TAG people see documents directly from that consultant, or did EPA internally review these documents, with their technical people, before they went to the TAG group?

RESPONSE: EPA reviewed them first, they were draft final versions.

5. **QUESTION:** Did you find, when you first started working with the Community Group, that they were organized to the point that they were ready to apply for the Technical Assistance Grant, or anxious to do so, or was it something that had to be worked with?

RESPONSE: No, the group had to be formed. Going back to the initial meeting they had, there was difficulty because the area was settled with Portuguese with little English speaking ability. EPA community relations coordinators went out with bilingual material trying to generate interest for the group. At an early meeting with the City of New Bedford, one woman requested to be the project manager. She organized sign up sheets which were taken to the community.

6. **QUESTION:** Did you provide assistance or background for the incorporation process which the Community Group went through?

RESPONSE: They did that on their own. Problems developed with attaining Non-Profit Organization status through the IRS.

7. **QUESTION:** When initial newspaper articles (regarding a hazardous waste site) came out, was there any sort of direct response by the Navy, or did you just kind of let them go and continue with your community relations?

RESPONSE: We did a press release, and we also prepared several fact sheets which we took to the community. We put them in the post office, library, etc. We had already set up an information repository -- we had done a few of the preliminary things we would do for a CR. We did not respond directly to the newspaper article because they had taken all our words, distorted them, then devoted several pages to the distorted version.

8. **QUESTION:** When your press officer experienced loss of credibility, was there a communication strategy or any kind of a CRP in place?

RESPONSE: We did not have a CRP in place. We figured out our plan as events unfolded. We had never gone out and done interviews, never prepared a formal CRP. I can tell you now that the Navy does not like to be in that kind of a situation. As soon as we realize contamination on a site, we like to get started [with community relations]. The sooner you get started, the better off you are. We learned a valuable lesson in Mechanicsburg, and if nothing else, it was worth that experience.

9. **QUESTION:** Can you describe the situation in Mechanicsburg?

RESPONSE: We had PCBs in the drainage ditch, but that is not what was described in the paper. Mechanicsburg is a supply depot, where the U.S. keeps their strategic supplies on a 700 acre paved site. We keep strategic reserves of lead, chromium, manganese, etc. Mechanicsburg is a ship's parts control center. We have parts of ships in supply there. It's one of those sites that, in time of war, ships parts to whoever needs them. One of the things that was a problem for us when the state discovered the PCBs was that we could not identify their source because we had no record of having stored PCBs on that facility. We finally

discovered that we had rebuilt transformers there, and that was the source of PCB contamination. We did an extensive storm sewer evaluation to try to track down where the PCBs were coming from, and we had to replace portions of that storm sewer.

We had talked to the newspaper about other sites, though, including the site where we had buried outdated medical supplies from World War II. That's where the newspaper blew things out of proportion.

10. **QUESTION:** Is this a base where Navy personnel live, and what kind of Community Relations exist with the base people?

RESPONSE: We informed them first, because people on the base don't like hearing about a base problem from a neighbor or friend. They want to know about it first. They were kept informed through briefings.

11. **QUESTION:** On the Formerly Used Defense Sites, does the Corps conduct the community relations plan or is there some leftover military facility that handles it?

RESPONSE: If it's an active installation, the Corps provides technical support; the installation prepares the CRP. For remediation at active installations, there is a book called The Commander's Guide to Installation Restoration -- an Army publication from USATHAMA -- that says the responsibility of the installation commander is to be the paragon of environmental virtue. The cleanup of a site is his responsibility, so even if the Corps may be running everything else at a site, the chairman of the technical review committee is invariably the installation commander.

The CRP is usually prepared by active installations. We do offer to them to do the CRP and allow them to fine tune it, in which case we would turn it over to a contractor. The decision was made a long time ago that, with the number of sites we have in the Kansas City district, we would need an enormous number of people to prepare all the CRPs or even to manage that many contractors.

HEALTH AND SAFETY PANEL SESSION

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1. **QUESTION:** Is a hazardous waste site defined by OSHA? Example: An office trailer in the support zone. Do these workers need training?

   RESPONSE: There is an internal inconsistency within the standards. In Section E it is defined that if an employee is on site regularly, and has no exposure or potential for exposure, he still needs 24 hours of training and one day of on-site training. This includes everybody that enters the boundaries of the site.

   In Paragraph A of the standard: There must be an exposure from a hazard on-site for 120 to apply. The policy is, if there is a hazard the standard applies, if there is no hazard from the site then the standard will not apply.

COMMENT: Section A states that where exposures are known or potential then the standards apply if in one of 5 categories. The potential for exposure includes accidental exposure.

2. **QUESTION:** Does 1910.120 have a requirement for one Health and Safety Plan, rather than 50, one for each contractor on site. Should there be just one plan for the entire site?

RESPONSE: That is the way the standard is interpreted.

COMMENT: The contractor should approve the plans for the subcontractors.

COMMENT: There is no rule saying there has to be just one health and safety plan (HASP), but any others should be just as strict and specific as the prime contractors, to make life easier. It is the Prime Contractor's responsibility to oversee the subcontractor's HASPs.

COMMENT: The contractors write the HASP and the subcontractors must comply. It is not always the case where it is one site, one HASP, especially for very large sites where there are four or five major contractors. A better way to work it is one project, one HASP.

COMMENT: During contract solicitation, they normally require a HASP. Exceptions are when contractors onsite want a more restrictive plan. They may add to the minimum OSHA and Corps requirements.

3. **QUESTION:** Should contractor's health and safety record be a requirement for bid specs?

RESPONSE: For a request for proposals, the health and safety record is a factor. For an IFB it is not a factor. Contractors at this point should be aware of the requirements. Some major contractors, for example, the government, considered this a prequalification.

4. **QUESTION:** Congress passed a law about agencies assuming responsibility for worker training. Of the 1.8 million workers that qualify for this, 53% are firefighters, who have the highest risk, but are not adequately trained. Thirty-one percent are law enforcement agents, also high risk and one percent are hazardous waste workers who have a lot of

training. Doesn't the firefighter agency have a direct responsibility to provide adequate funding, as Congress had intended the money to be used, as in the case of firefighters with high legitimate claims to be trained rather than for EPA to assume responsibility.

RESPONSE: The request for training is very competitive. Many agencies apply, but only a few get it. This agency has filled their obligation thus far with the money that is available. If there is more money, there will be more training. The Hazardous Materials Transportation Act of 1990 is providing a grant program at the local level through public sector agencies. When this grant goes through, there will be more training from the fire service.

5. **QUESTION:** If the funding is inadequate, why not go back to Congress and say there is not enough money for training, so these people can do their jobs effectively. It seems as though the money is going to the wrong people. Educational Institutions should not be getting the funding because they do not have the authority to help. People who do the work should be getting the money.

RESPONSE: The President's budget cut the programs funding in half. Appropriations are fighting it now.

6. **QUESTION:** What is to be done with utility companies wanting to come on site for routine maintenance, main breaks, etc. Should they have a trained contractor on site with them? Is it okay to just have a site safety person out there to make sure that the utility company complies with the site HASP? How does OSHA feel about this? Is this a violation to have them on site?

RESPONSE: OSHA says there must be site representative who is trained with a trained person monitoring. All utilities should have properly trained people.

COMMENT: We must coordinate very early on. If you know there are gas mains and underground utilities, there is plenty of time before an investigation begins to contact utilities and make them aware of what is to come on this site. Be prepared because there is no excuse to send untrained workers onto the site to be exposed to what is there.

COMMENT: These utility people won't be going onto the sites very often.

RESPONSE: It is not okay to send untrained personnel on site.

COMMENT: There are contractors available to work for utilities that have people that are properly trained. There is no reason for utility companies to put people's lives in jeopardy by sending untrained workers onto a hazardous waste site. If utilities don't have qualified people, there are contractors who do.

7. **QUESTION:** What is going on around the country before we come into town and say we have Superfund site? How are the communities and responders, gas companies, firefighters, etc., handled prior to the listing of Superfund site? As far as training is concerned, focusing only on Superfund is hitting only on a limited portion of the market.

RESPONSE: Superfund is such a small portion of what trainers have to deal with. Many fire chiefs, etc., are stuck to tradition, not training. When dealing with them (firefighters) on Superfund sites, you get the same kneejerk reaction as with various other kinds of exposures. It is very tough to get the cooperation needed that you get from the Corps of Engineers and the EPA.

COMMENT: Concerning the planning step of emergency response, having this carried out at the remedial action phase by the construction contractors will not only entail the fire department but some of the issues on utility services, etc. It is an issue that is difficult with the Corps of Engineers in execution. If it is difficult to affect the execution of the emergency response plan because the service providers are not trained or properly equipped to perform the service. My recommendation for this conference is that the support of a task force that would look at the review process prior to design in terms of the community service based around a selected site and go through a thorough fact finding process to delineate the best course of emergency response that can get plugged into design.

COMMENT: There has to be cooperation from the government to recognize that they must get out more information and get it out in a more timely manner. Also, the need is the same from emergency responders. In the past, when looking at any federal documents with requirements a contractor could assume that these requirements were being met. So in a situation dealing with a large union, such as the fire fighters, you go into a town, coordinating with town officials and a fire chief. If in fact that is not the way this needs to proceed, then that word has got to get out to the contracting and government community because it is a fairly logical assumption to make, that if the fire chief says he can respond there will be a response and there won't be any question as to whether his people are trained. From both sides there has to be a clear view of what all the issues are.

CONCLUSION: We are all now witnessing EPA, Corps of Engineers, and experienced trainers all working together for Health and Safety. One year ago you wouldn't have seen this. Hopefully, there will be more progress in the year ahead, especially with training in emergency response.

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I. CASE STUDIES

Composite Concrete Liners for Radioactive Wastes

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INTRODUCTION

The requirements, under Minimum Technology Guidance by Environmental Protection Agency (EPA), for hazardous waste landfills and surface impoundments were introduced by Hazardous and Solid Waste Amendments of 1984. Double liners and leachate collection systems have been used extensively for the disposal of hazardous wastes. Clay and high density polyethylene (HDPE) have been the preferred choice for lining materials. However, for the disposal of radioactive wastes, reinforced concrete liners with HDPE as a composite liner is considered to be an effective alternate. This paper reports the details of concrete grout vaults and its features to meet the minimum technology criteria and Department of Energy orders. The selection of liners, barriers and materials for construction is also discussed. The use of concrete as a component of the composite liner system is unique for the disposal of radioactive wastes and its applications for other wastes may be equally appropriate.

OVERVIEW

Since 1943, the Department of Energy (DOE) has been receiving defense related radioactive wastes at the Hanford Reservation (site), located in the southeast region of the State of Washington. The site covers 560 square miles and is in an arid climate on the banks of the Columbia River. About 340,000 people reside within a 50-mile radius of the site. In the past, DOE's missions at the Hanford Site included plutonium separation, energy technology development, and waste management. A variety of low-level/high-level radioactive wastes (LLW/HLW), hazardous or plutonium contaminated wastes in the form of "salt cake," sludge, and liquid are stored in underground storage tanks. LLWs are generated by the medical, research facilities and the high level concentrations are the end products of defense related projects and nuclear power plants. To comply with recent decisions within DOE, the wastes have to be treated and disposed of in accordance with state and federal regulations.

Radioactive wastes consist of large volumes of material containing relatively low concentrations of radioisotopes, as well as, smaller volumes of more highly concentrated materials. Depending on the type of radiation, half-life and dose rate, the risk to human health and environment differ. Based on these factors, radioactive wastes at the Hanford site are classified into low-level, high-level, mixed, and transuranic wastes.

Radioactive wastes are stored in single shell tanks (SSTs) and double shell tanks (DSTs). Approximately 37 million gallons of radioactive wastes are stored in 149 single shell tanks. Sixty-six SSTs were confirmed or suspected to leak. Stabilization of SSTs is a top priority in the Tri-Party Agreement, an inter-agency blueprint for corrective and remedial action at the Hanford Site between EPA, DOE, and Washington Department of Ecology (WDOE). Stabilization will involve isolation of the tanks and removal of pumpable liquid for disposal. Solidification, by mixing liquid radioactive waste with cement grout, is identified as a permanent means of disposal for mixed wasted and LLW.

SITE

The site for the vaults, located in the 200 Area of the Hanford Site, lies in the Central Plains of the Columbia River Basin. The foundation soil for vaults consists of gravels and silty-fine sand. The depth of the ground water table is approximately 260 feet. The storage and processing facilities for DOE are located within the basin of the Columbia River, which is a major source of water for municipal, industrial, recreation, and irrigation purposes for the States of Washington and Oregon.

GROUT TECHNOLOGY

Solidification of waste in a grout matrice appears to be a viable option for the long term disposal of LLWs, HLWs and mixed wastes. Wastes removed from the tanks will be pre-treated to reduce the volume prior to disposal. The high-level/transuranic wastes from the tanks will be targeted for vitrification. Grout technology involves mixing waste slurries with cement, water, fly ash and (sometimes) clay, and poured into concrete vaults to allow solidification such that the contaminants are immobilized. Current methods of solidifying radioactive wastes are a slow process and migration of leachate, during fixation and retention, should be prevented. Grout is a low-cost, low-energy technology with wide applications for the Hanford Site. EPA's remedial investigations indicate that the grout technology will likely be the leading candidate for immobilization of contaminated soils and wastes stored in tanks. Because radioactive wastes emit heat energy over a long period, durability of the waste form is questionable. In the 1990-95 five-year plan, DOE has scheduled to initiate a full-scale demonstration and obtain data on durability by 1995 before implementation.

DESIGN CRITERIA

All radioactive wastes, except mixed wastes, are regulated under Atomic Energy Act and Nuclear Waste Policy Act and their amendments. The Nuclear Regulatory Commission and the Department of Energy are the regulatory agencies for the disposal of waste. Since 1984, the mixed wastes processing and disposal were subjected to National Environmental Policy Act, Resource Conservation and Recovery Act and Comprehensive, Environmental, Responsibility and Compensation Act. The design and construction of the vaults are subject to the requirements of the Resource Conservation and Recovery Act, Dangerous Wastes Regulations of the State of Washington, and the Department of Energy Orders 5820.2A and 6430.1A. ANSI/ASTM NQA-1 is the standard for the quality assurance, in addition to Construction Quality Assurance requirements of EPA for hazardous waste facilities. Radiation exposure, according to DOE orders, is that the effluent or air escaping from the unit be limited to site standards - effective dose equivalent shall not exceed 25 mrem/year to any member of the public.

In addition to standard design criteria for nuclear facilities, the vault must be designed to withstand a maximum operating temperature of 90 degrees Centigrade and prevent intrusion of or retention of water from rain, snow melt or other sources. Long term release of radionuclides and chemical constituents shall be limited to 1×10^{-2} cm/sec and the vapor barrier shall be designed to limit escape of vapors to 1×10^{-5} cm/sec.

VAULTS

Four concrete vaults are now under construction at the site. The vaults are constructed of reinforced concrete with a catch basin to serve as leachate collection and removal system. The inside dimensions of the vault are 123 feet long, 50 feet wide and 34 feet high and the capacity is 1,400,000 gallons (Fig. 1). The concrete mix consists of cement and aggregate mixed with 20 percent pozzolan to meet a compressive strength of 4500 psi. The vault is isolated by a diffusion barrier at the base and sides to prevent migration of leachate to the soil. Vaults are designed to receive the slurry above 150

degrees Fahrenheit. The barriers, vertical leachate drains, and concrete HDPE composite liners are some of the unique features of this project. With a .32 water-cement ratio, installation utilizes unique curing and thermal controls for the mix to insure additional integrity for thermal cracking from the grout mix.

LINER SYSTEMS

The vaults are designed with two component liner (composite) systems and a leachate collection system. The primary composite liner system will be an elastomeric urethane asphalt coating applied to interior vault wall concrete. The secondary composite shall be of HDPE liner attached to the concrete of the catch basin.

The elastomeric asphalt coating was analyzed for its engineering properties and tested for capacity to span shrinkage and thermal cracks in concrete. The coating is capable of counteracting shear stress due to the grout and its in-place ability to bridge cracks in the concrete was tested in the laboratory. The coating will consist of Lion Nokorode 705M and will be applied, at a rate of 2 gal/100 sqft, for a total dry film thickness of 75 mil. Unlike coal-tar coatings, the elastomeric is compatible with a radioactive waste and grout formulation. The secondary composite is HDPE laid over the concrete basin and anchored by stainless steel batten strips.

In the primary and secondary composite liners, concrete serves as the backbone of the system. Though vastly different from clay liners, a typical feature of most hazardous waste landfills, the concrete plays a dual role in the concrete vaults. Concrete has a low permeability in the range of $1x10^{-11}$ cm/sec, ten thousand times lower than clay. To achieve watertightness, impermeable concretes with a low water-to-cement ratio and moist curing (7 days) are specified. Though expensive, concrete liners are the preferred choice due to the structural, thermal, solidification, and radioactive considerations.

DIFFUSION BARRIER

A diffusion barrier serves as a cocoon for the vault to prevent migration of vapor and infiltration of moisture from the soil. The cocoon is designed to achieve a vapor diffusion $1x10^{-10}$ cm/sec and to isolate the waste from the environment. The cocoon is 36 inches thick and, due to limiting water vapor transmission the barrier is designed to be virtually watertight and prevent migration of leachate to the soil column below. The diffusion barrier is made of graded gravel treated with an anti-stripping additive to improve surface oil adhesion. The liquid asphalt AR-6000W is used at 7.0$\pm$ percent by weight of total mixture. Lime is used as an anti-stripping agent at 2.5 to 3 percent by weight of mixture to pretreat the aggregate prior to mixing with asphalt.

LEACHATE COLLECTION SYSTEM

The vault is supported by a catch basin (pan) wherein the leachate collection system and pipes transport the leachate to the sump. The secondary composite liner consists of the concrete floor of the basin and the HDPE liner. The basin is lined with 60 mil HDPE and drain pipes transport leachate to a sump with level sensors to activate the pump. The sump is a carbon steel collector encased in concrete. A highly permeable diffusive layer of gravel (18 inches thick) separates the vault from the basin and transmits dead loads in excess of 8000 pounds per square feet. The impact (creep) due to gravel loads on the HDPE liner is mitigated with a layer of geotextile.

DRAINAGE PATH

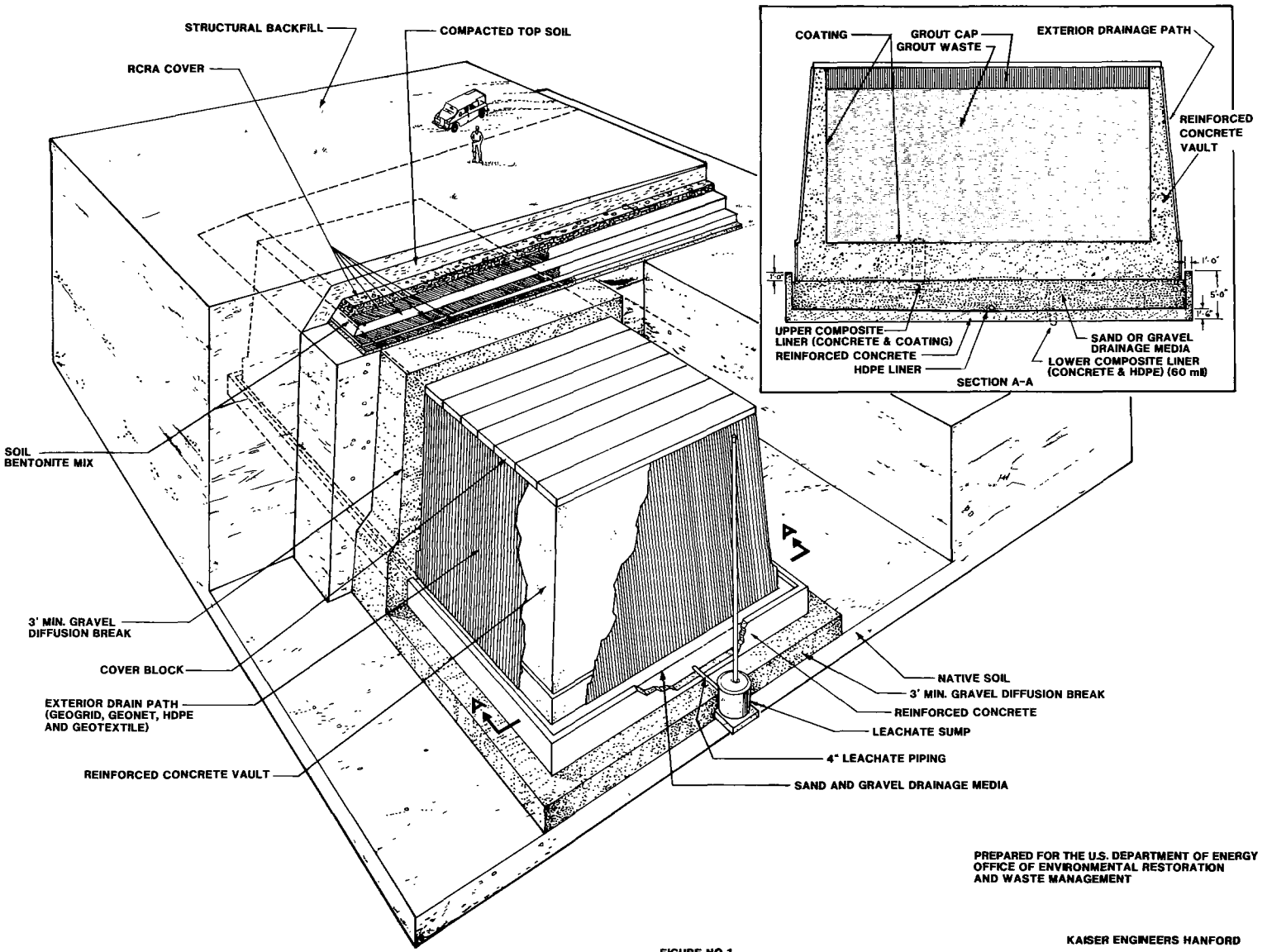
On the vertical sides, the vault is also provided with a drainage path to transmit the leachate to the catch basin below. The drainage path consists of a layer of geotextile, geomembrane, and geonet laid against the sides of the vault and separated from the asphalt by a thermal board. Due to the heat generated by the asphalt during placing and solidification, the drain path needs to be separated by thermal insulation to avoid damage to HDPE components.

SUMMARY

Cement concrete can be an effective alternate liner material for hazardous waste and radioactive waste disposal sites. In locations, where native soil is a limiting factor for clay or soil/bentonite liners, concrete as a component for composite lining should be explored. In desert climates, where desiccation cracking may impact clay or soil/bentonite liners, concrete liners provide an alternative choice. Due to rigidity of concrete, the designs should accommodate special coatings to span the cracks to protect the integrity of the disposal sites.

The cost of concrete liners will be expensive compared to other admix liners and geosynthetic materials. For equivalent thickness, concrete weighs more and the foundation costs will be significant. However, if the integrity and compatibility can be achieved while reducing the thicknesses, it is possible that concrete linings can be a viable alternative for hazardous waste sites too.

GROUT WASTE DISPOSAL VAULT



PREPARED FOR THE U.S. DEPARTMENT OF ENERGY
OFFICE OF ENVIRONMENTAL RESTORATION
AND WASTE MANAGEMENT

FIGURE NO.1

KAISER ENGINEERS HANFORD

NO SCALE 247190 5/4/88 KRUEGER

Fast-Tracking Remedial Design at the Cape Fear Wood Preserving Site

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INTRODUCTION

Fast-tracking, a method to accelerate remedial design and remedial action projects by eliminating and/or rearranging various tasks, can be successfully applied to the remedial design and remedial action work elements in the cleanup of hazardous waste sites. This paper presents a case history in which innovative fast-tracking techniques were applied to a Superfund Site remedial design. Although this project did not exhibit all the characteristics usually conducive to fast-tracking, it was completed in an expeditious manner by omitting tangential design tasks, carefully scheduling select tasks, and combining intermediate and prefinal design. Most importantly, a preliminary design meeting was held with the U.S. Environmental Protection Agency (EPA) and representatives of the U.S Army Corps of Engineers and the State of North Carolina during a critical phase of the project to resolve key design issues and facilitate design completion.

In August 1989, EPA retained Camp Dresser & McKee Inc. (CDM), through its Federal Programs Corporation subsidiary, to complete a remedial design of the Cape Fear Wood Preserving Site, an abandoned wood treating facility located in Fayetteville, North Carolina. EPA's original Statement of Work included twelve major design tasks, each typical of a remedial design work assignment for a Superfund site. The original Statement of Work called for completion of the project by the end of the 1990 calendar year. After the Final Work Plan was approved, EPA, in an effort to obligate funds for the RA phase, directed CDM to finish the design by the end of EPA's fiscal year 1990. As a result, five major changes were made to the original scope of work, three tasks were eliminated, and the design schedule was ultimately shortened by approximately two months.

This paper presents a history and description of the Cape Fear Site and elements most suited to fast-tracking, compares the original and final scope of work for the site, and presents specific techniques used for fast-tracking the remedial design for this project.

BACKGROUND

Site Description

The Cape Fear Site is located in Cumberland County, North Carolina, on the western side of Fayetteville near Highway 401 and along Reilly Road (Figure 1). The site includes approximately 9 acres of a 41-acre tract of land adjacent to other industrial/commercial establishments as well as

private residences. Four homes are located near the site. In addition, a subdivision is located a quarter of a mile south of the site and houses approximately 1,000 people.

The terrain of the Cape Fear Site is predominantly flat, with drainage provided by a swampy area on the northeast side of the site and a man-made ditch to the southeast that extends southeastwardly from the site. A variety of land uses exist around the Cape Fear Site. The properties to the north include a pine forest, a concrete plant, and a few residential properties. To the east is a continuation of the pine forest, and to the west is farmland used for growing crops and raising livestock. A second concrete plant and the subdivision are located to the south.

Site History

History of Contamination. Operations at the Cape Fear Site commenced in 1953 and continued until 1983.[1] The Cape Fear Wood Preserving facility produced creosote-treated wood from 1953 until 1978 when demand for creosote-treated products declined. Wood was also treated by a wolmanizing process using salts containing sodium dichromate, copper sulfate, and arsenic pentoxide, known as the copper-chromium-arsenic (CCA) process. The date the CCA process began at the site is not available, nor is it known whether the creosote and CCA processes occurred simultaneously.

Both liquid and sludge wastes were generated by the treatment processes and pumped into a sump north of the treatment area (Figure 2). As liquid separated from the sludge, it was pumped into a drainage ditch that extends southeasterly behind the developed portion of the site and into a diked pond. Stormwater runoff from the treatment yard also flowed into this drainage ditch. In addition, waste from the CCA treatment process was pumped into an unlined lagoon north of the dry kiln.

In 1977, the site was determined to be contaminated with constituents of coal tar and coal tar creosote. State authorities ordered the owner/operator to take measures to comply with North Carolina law. As a result, operations at the facility were changed to limit further releases, a new water well was installed for a resident living west of the site, and 900 cubic yards of contaminated soil were transported for land-spreading to a leased property approximately 2.5 miles south of the site.

Sometime between 1979 and 1980, a new closed-circuit CCA system was installed and the old creosote and CCA facilities were decommissioned. The new CCA plant was regulated under the Resource Conservation and Recovery Act (RCRA) as a small quantity hazardous waste generator until 1983. When the company went out of business, the site was subsequently abandoned.

Initial Investigation and Remedial Measures. EPA conducted a site reconnaissance and site investigation in October 1984. As a result, emergency removal actions for sump sludge, lagoon sludge, lagoon wastewater, and selected contaminated soils (ditch and northeast seasonal swamp) were undertaken in 1985. Later in 1985 another investigation was undertaken, resulting in a second emergency response being conducted in 1986 to remove contamination caused by a creosote spill.

Recent Investigations and Studies. A remedial investigation characterizing the nature and extent of contamination was conducted under the REM II contract by CDM from April 1987 to October 1988.[2] The feasibility study presenting cleanup goals for the contaminated media and evaluating possible remedial action alternatives for the site was also developed by CDM and completed in December 1988.[3] EPA signed the Record of Decision (ROD) on June 30, 1989, and in August 1989, EPA contracted with CDM to begin a remedial design at the site.[4] A Remedial Design Work Plan, prepared by CDM, presented the scope of work, technical approach, management plan, schedule, and staffing requirements to complete the remedial design.[5] Additional project planning documents prepared by CDM during the remedial design included a Field Operations Plan, Quality Assurance Project Plan, Health and Safety Plan, and a Community Relations Plan. Design documents were also prepared

between August and September 1990 that included a design report and plans and specifications for site remediation.[6]

Summary of the Remedial Investigation. During the remedial investigation, CDM discovered that records concerning the exact nature and quantity of wastes disposed onsite were not available. Information obtained from representatives of the Cape Fear Wood Preserving Company, however, indicated that the only chemicals used in the wood preserving processes were creosote and wolmanizing salts containing a copper-chromium-arsenic mixture. The type of carrier oil was not identified.

Past investigations indicated extensive site contamination with polycyclic aromatic hydrocarbons (PAHs), and to a lesser extent, copper, chromium, and arsenic. The soil was contaminated in several areas. In addition, volatile organic compounds (VOCs) resulting from a leaking underground storage tank were observed at the site in a localized area. Even though most of the soil contaminants have a low water solubility, the close proximity of the groundwater to land surface had apparently facilitated the migration of contaminants into the groundwater system, as evidenced by contaminated groundwater samples.

Summary of the Feasibility Study. As part of the feasibility study project, cleanup goals were derived for chemicals of concern at the Cape Fear Site. Chemicals of concern and exposure pathways had been detailed in a previously conducted risk assessment and were reviewed where pertinent to the derivation of cleanup goals. Potential remedial technologies were also identified and screening was conducted to eliminate treatment and containment options that were not feasible or were impractical.

Summary of the Record of Decision. The ROD was issued by EPA in June 1989 and mandated remediation of groundwater, soils, sediments, and surface water bodies. In addition, various waste materials stored onsite were targeted for cleanup. EPA's preferred remedy for soils was either soil washing or low temperature thermal desorption to remove organic contaminants followed by either soil washing or solidification to address the inorganics. EPA desired to determine the most suitable remedy for mitigation of soils based on results of treatability studies to be conducted during the RD.

Summary of the Remedial Design. A design was developed to incorporate EPA mandates identified in the ROD. A flow diagram showing the various mitigation pathways is presented in Figure 3. This flow schematic formed the basis of resulting design documents. In addition, CDM performed treatability studies and conducted various field investigations at the site during the remedial design. The resulting product of the RD included a design report and plans and technical specifications for site remediation.

DISCUSSION

Fast-Tracking Remedial Design Projects

Fast-tracking is a technique used to optimize project schedules by manipulating the tasks required to complete the overall project. Fast-tracking generally eliminates and/or rearranges the tasks involved in a project. Because tasks are often interrelated, eliminating tasks must be done carefully to avoid problems later in the project. Rearranging the order or timing in which the tasks are performed can expedite the overall project schedule. The less complex a project, the more amenable it is to fast-tracking. In addition, projects that display particular traits are more easily accelerated using fast-tracking techniques. These characteristics and their application to the Cape Fear Site are discussed below.

The Proposed Remedy Utilizes a Proven Technology. Soil washing is a proven technology but remains in the developmental stages for full-scale implementation. Low temperature thermal desorption, although proven to be effective on certain organic contaminants, minimum temperatures required to volatilize PAHs were unknown. In addition, because the ROD did not specify particular technologies, additional evaluation was required before the design could begin. As a result, this trait was not characteristic of the Cape Fear project.

Treatability Studies May Not be Required. Alternately, they may have already been completed during the remedial investigation or feasibility study, and only minimal additional field data are required. Again, a treatability study was required by the ROD for the Cape Fear Site, so this trait was not typical for this project.

A Value Engineering Study May Not be Required. A value engineering study was included in the original Cape Fear Site scope of work but was eliminated as part of the fast-tracking process. Although a value engineering study was not conducted, CDM reconciled this by conducting internal formal technical reviews, which allowed CDM to expedite the schedule without sacrificing quality of the design product.

Intermediate Design Tasks May Not be Required. The intermediate design task was included in the original scope of work, but was eliminated to expedite the project schedule. Continual communication between CDM and EPA was crucial during this phase of the project to avoid additional design revisions.

The Site and Conditions Present no Unusual Property Access Problems or Permitting Requirements. The Cape Fear Wood Preserving Company is no longer in operation and the owners have been responsive to EPA's involvement in remediation of their property. In addition, environmental permitting requirements are expected to be minimal (i.e. an NPDES permit for discharge of treated water from the site will be required). Therefore, this characteristic applied to the Cape Fear project.

Evolution of the Scope of Work

The decision to fast-track the remedial design at the Cape Fear Site was not made during the initial planning stages. In fact, it was decided after approval of the Work Plan and after an actual date had been established by EPA for delivery of the final design. This section describes how the scope of work evolved throughout the project. An overview of the project history is shown in timeline form in Figure 4.

The original scope of work prepared by EPA consisted of twelve tasks. These tasks are presented in Table 1. During the initial scoping meeting in October 1989 between CDM and EPA, it was decided that the soil washing pilot study would be incorporated into the remedial action phase. A treatability study originally proposed for treatment of contaminated aqueous streams, was eliminated during this meeting since it was determined that standard technologies could be used to treat these streams based on expected contaminant levels. It was further decided to postpone the bid evaluation process until the remedial action phase.

By November 1989, CDM had completed draft versions of the Remedial Design Work Plan, the Field Operations Plan, the Health and Safety Plan, and the Community Relations Plan. These plans were reviewed by EPA and approved in January 1990 with an agreed upon completion date of September 28, 1990 for delivery of final design documents. CDM then began subcontractor procurement activities; however, bid packages sent out for drilling services, geotechnical services and soil washing treatability testing had unforseen complications which precluded subcontract award consistent with the approved work plan project schedule. These complications included lack of bidder response and

low bids exceeding the budgeted subcontract amount. Field activities were subsequently delayed.

In March 1990, an additional change in scope was made. In order to be eligible for remedial funds, a design, complete with drawings and specifications, needed to be completed by the end of the third quarter of the fiscal year. Therefore, to ensure funding; EPA divided the remedial design efforts into two operable units. The first phase, which was not dependent on the results of field work and treatability study, would be expedited and completed by June 30, 1990, and the design for the second phase would be completed no later than October 31, 1990. CDM then prepared and submitted a preliminary design report for the first phase of the design on April 16, 1990.

Shortly thereafter, EPA decided to combine the remedial design of both operable units, and sought to have final design documents submitted to EPA by the end of September 1990. This gave CDM approximately 5 months to complete the design. To expedite the schedule, it was necessary for CDM to modify the critical path schedule and associated tasks. After careful evaluation of work assignment tasks, CDM developed a fast-track schedule for implementing the remedial design. It was imperative that no delays in the field work or the treatability study occur and that CDM receive concurrence with EPA, the State of North Carolina, and the U.S. Army Corps of Engineers on critical design issues at the 30% design phase. In addition, EPA and peer review would be reduced from four weeks to three weeks. This latest change in scope required that all field work begin on April 30, 1990 and the treatability study start on May 7, 1990. The final scope of work, dated April 1990 included the results of fast-tracking and is presented in Table 2.

Techniques Used for Fast-Tracking

Virtually all remedial design projects can take advantage of fast-tracking techniques to expedite schedules; however, certain fast-tracking techniques used on some projects may not be applicable to others. EPA has identified the following techniques that can be used to fast-track remedial design projects.[7]

Reduce the Detail Required in the Design Documents. This may include eliminating detailed design drawings (plans) and specifications and instead preparing a site layout drawing and a basic description of the work to be performed. This works best for simple remediation sites, such as pump and treat systems or excavation and disposal of small quantities of contaminated soil. If the recommended cleanup is more complex, the use of "performance" type specifications can be used. Performance specifications are written to specify certain performance criteria that a contractor must meet, and do not involve detailed equipment specifications that require more time to develop.

Use Standardized Sets of Specifications. Many engineering firms have developed standard "generic-type" specifications that are used from one project to another. In addition, various equipment manufacturers have prepared standard sets of specifications for specific treatment equipment. Caution should be exercised in their use, however, since they are general in nature, and the proper modifications should be made to incorporate site-specific conditions and issues.

Use Existing Plans. Where possible, information from existing plans previously prepared during the remedial investigation and feasibility study stage should be used, such as a Health and Safety Plan, Quality Assurance Project Plan, and Community Relations Plan. Although the actual plans may not be reusable, information relating to site conditions and nature of contamination may be used to help prepare the corresponding plans for the remedial design.

Provide Project Continuity. For an EPA-lead site, considerable time is saved in the transition from the ROD to remedial design if the same EPA contractor performs the remedial investigation,

feasibility study and the design. The benefits are that EPA already has a working relationship with the firm and the firm has an established project file and is familiar with the site.

Expedite Access Agreements. Site access agreements during the remedial investigation and feasibility study phase should be structured to also allow for site access during design activities. Access and real estate concerns can be very time consuming and complicated. Considerable time is saved if these concerns are addressed early in the project.

Conduct Parallel Design Reviews. Time is saved if design reviews are scheduled in parallel with continuing design work so they are not on the critical path. In many cases, review of design documents by state agencies and oversight firms can take place concurrently with EPA review. Another time-saving technique is to invite agency personnel to in-house technical reviews conducted by the engineering firm during early stages of the project. By doing this, EPA concerns are incorporated concurrently with review comments identified by the engineering firm.

Schedule Value Engineering Studies Efficiently. If a value engineering study is required, it should be scheduled separately from the design critical path. The results of the value engineering study should be incorporated into final design documents.

Almost all of these fast-tracking techniques were used to some extent during the Cape Fear project as depicted in Table 3.

The fast-tracking techniques discussed above can be applied to any remedial design project. Each project, however, should be evaluated on a site-specific basis to determine the most appropriate means to expedite the schedule. In other words, a strategy should be developed to expedite the project that is best suited to meeting project-specific milestones and client objectives.

As the scope of work evolved for the Cape Fear project and the need to fast-track the design became more evident, a logical plan was developed to meet the schedule objectives of EPA. This plan contained four key components:

- Eliminating unnecessary design tasks
- Combining intermediate and prefinal/final design tasks
- Efficient planning of the treatability study
- Conducting a 30% design review meeting with EPA

Each of these techniques was used by CDM to fast-track the design and prepare a final project schedule as shown in Figure 5.

Elimination of Unnecessary Design Tasks. In order to meet EPA's September 30th deadline, CDM proposed to eliminate several design tasks (or subtasks) identified in the original work plan that were not required to meet objectives of the final deliverable documents. The subtasks eliminated included preparing a separate treatability study report, conducting a value engineering study, and preparing a complete bid package. A separate treatability study report was not required since it was decided to incorporate this report into the design report. A value engineering study was deleted due to time requirements to conduct the study and the fact that extensive quality assurance measures allowed for in-house reviews prior to document submittal. Finally, a decision was made by CDM and EPA to limit design documents to technical specifications and drawings during the design phase. That is, CDM prepared technical specifications and drawings without specific bidding instructions and

contract terms and conditions. These "front-end" contractual documents would be incorporated as a first task under the remedial action phase.

Two other subtasks were eliminated as a result of combining the intermediate and prefinal/final design tasks (described in detail below). These included preparing a final design report and preparing intermediate design plans and specifications representing 60% design completion.

Combining Intermediate and Prefinal/Final Design Tasks. A second component used in fast-tracking at the Cape Fear Site involved combining the intermediate and prefinal/final design tasks into one final design task. The original scope of work included the following three tasks for the design portion of the project:

(1) Preliminary Design (comprised of four subtasks: performing a groundwater extraction analysis, designing a water treatment system, designing a soil treatment system, and preparing a preliminary design report)

(2) Intermediate Design (comprised of two subtasks: preparing a final design report and preparing 60% plans and specifications)

(3) Prefinal/Final Design (comprised of two subtasks: revising the 60% plans and specifications for a 90% design submittal and revising the 90% plans and specifications for the 100% design submittal)

The final scope of work for the design portion using fast-tracking included two tasks:

(1) Preliminary Design (comprised of five subtasks: performing a groundwater extraction analysis, designing a water treatment system, designing a soil treatment system, preparing a single design report, and preparing 90% plans and specifications)

(2) Final Design (comprised of one subtask: revising the 90% plans and specifications for the 100% design submittal)

The net result was the elimination of two subtasks. In addition, the design report and 90% plans and specifications were prepared concurrently and submitted to EPA at the same time. This resulted in only one design review prior to preparation of the final design documents. In order to overcome this possible shortfall in quality assurance, a 30% design review meeting was added as a critical component of the fast-tracking plan that occurred prior to beginning the design report and 90% design documents.

Efficient Planning of the Treatability Study. A third technique used to fast-track the remedial design involved careful scheduling of the treatability study so that results of the study would be available at the appropriate time. The treatability study was conducted in approximately 15 weeks and involved bench-scale testing for soil washing, low temperature thermal desorption, and solidification. Since the objective of the treatability study was to determine the most suitable treatment technology for contaminated soils, it was critical that the final results be available prior to the final design task. The treatability study was planned so that the results of soil washing and thermal desorption would be available prior to beginning the design report and 90% plans and specifications, and the results of the solidification test were available prior to beginning the final design submittal.

Conducting a 30% Design Review Meeting With EPA. A final component of the fast-tracking strategy, and perhaps the most important, was conducting a 30% design review meeting with EPA and

peer review parties. The purpose of this meeting was to review all work performed by CDM to date and resolve critical design issues to allow for project completion by the September 30th deadline. The 30% design review meeting was a working session conducted before starting work on the design report and 90% plans and specifications. The meeting was attended by EPA, State representatives, the U.S. Army Corps of Engineers, and CDM project staff. Key design factors were discussed and agreed upon by all parties. These design factors included methods of water and soil remediation, methods of hazardous materials remediation, preferred discharge alternative for treated water, and type and format of the design documents. In order to proceed with subsequent design tasks and meet the agency deadline, it was important to resolve these design factors early in the project.

Keys to Successful Fast-Tracking

Based on CDM's design experience at the Cape Fear Site, four key factors have been identified that are critical to the success of fast-tracking a remedial design project.

Develop a Schedule and Abide by It. A schedule for fast-tracking should be developed as soon as the need arises to expedite the project. Assumptions used to implement the schedule should be written down and discussed with the client. Most importantly, the schedule should be rigorously adhered to, and when deviations arise, necessary modifications should be made so that project deadlines are maintained.

Maintain Communication With the Client. Constant communication with the client is a must when implementing a fast-track design project. This can be accomplished through weekly status reporting and/or conducting regular briefings to inform the client of the project status and any expected deviations in the project schedule. It is important for the client to understand the complexity of each task, how long it will take, and if the task is on the critical design path.

Resolve Critical Design Issues Early On. Immediate steps should be taken after conducting site investigations and evaluating the data to define key design factors, determine or estimate these factors, and obtain client "buy-off". Critical design factors may include treatment flow rates, volumes of soil and groundwater targeted for cleanup, disposal alternatives, specific methods and technologies for remediation (if not already defined in the ROD), preliminary equipment sizing, estimated treatment duration, budgetary costs for site remediation, and type and format of the final design documents. This was accomplished on the Cape Fear project by conducting a 30% design review meeting with the client and review parties. The objective is to determine key design parameters early in the project and obtain client concurrence so that subsequent tasks can be completed on time.

Plan and Implement Efficient Use of Staff Resources. Schedule compression due to fast-tracking results in more staff resources being utilized over a shorter period of time. Before fast-tracking commitments are made, adequate and qualified staff should be identified and assigned to the project. The client should be aware of increased staffing requirements that results in additional coordination efforts which may lead to increased project costs. These increased costs may, however, be offset by cost savings related to shortening the project schedule and eliminating certain tasks.

CONCLUSIONS

Fast-tracking the remedial design was used successfully at the Cape Fear Site to meet EPA-established deadlines, and resulted in shortening the project duration by about two months. This is considered exceptional due to the fact that the original project schedule was based on virtually no slack time and assumed that procuring of subcontractors and conducting field work would take place without delay. The results of fast-tracking also revealed that in a 5-month period the following tasks were

successfully completed: an extensive site investigation lasting over one month that involved five subcontractors, a 15-week long treatability study utilizing three subcontractors, and design of site remediation resulting in a two-volume design report and complete technical specifications and construction drawings to be used in selecting a contractor for cleanup.

It should also be noted that this project did not exemplify some of the characteristics of projects most suitable for fast-tracking. This is demonstrated by the fact that the proposed treatment technologies for soil remediation were either unproven technologies or in the early developmental stages. For instance, soil washing has never been used on a full-scale basis at a Superfund site and solidification of PAH compounds is relatively new. As a result, treatability studies were required for this project to identify a suitable soils treatment scheme.

Fast-tracking techniques used at the Cape Fear Site included those identified in EPA guidance documents and others implemented by CDM based on project-specific conditions, including: elimination of unnecessary design tasks, combination of intermediate and prefinal/final design tasks, proper scheduling of the treatability study, and conducting a 30% design review with EPA.

Keys to successful fast-tracking on remedial designs include dedication to a rigid project schedule, maintaining constant communication with the client, identifying and resolving key design factors early on, and making the most efficient use of staff resources.

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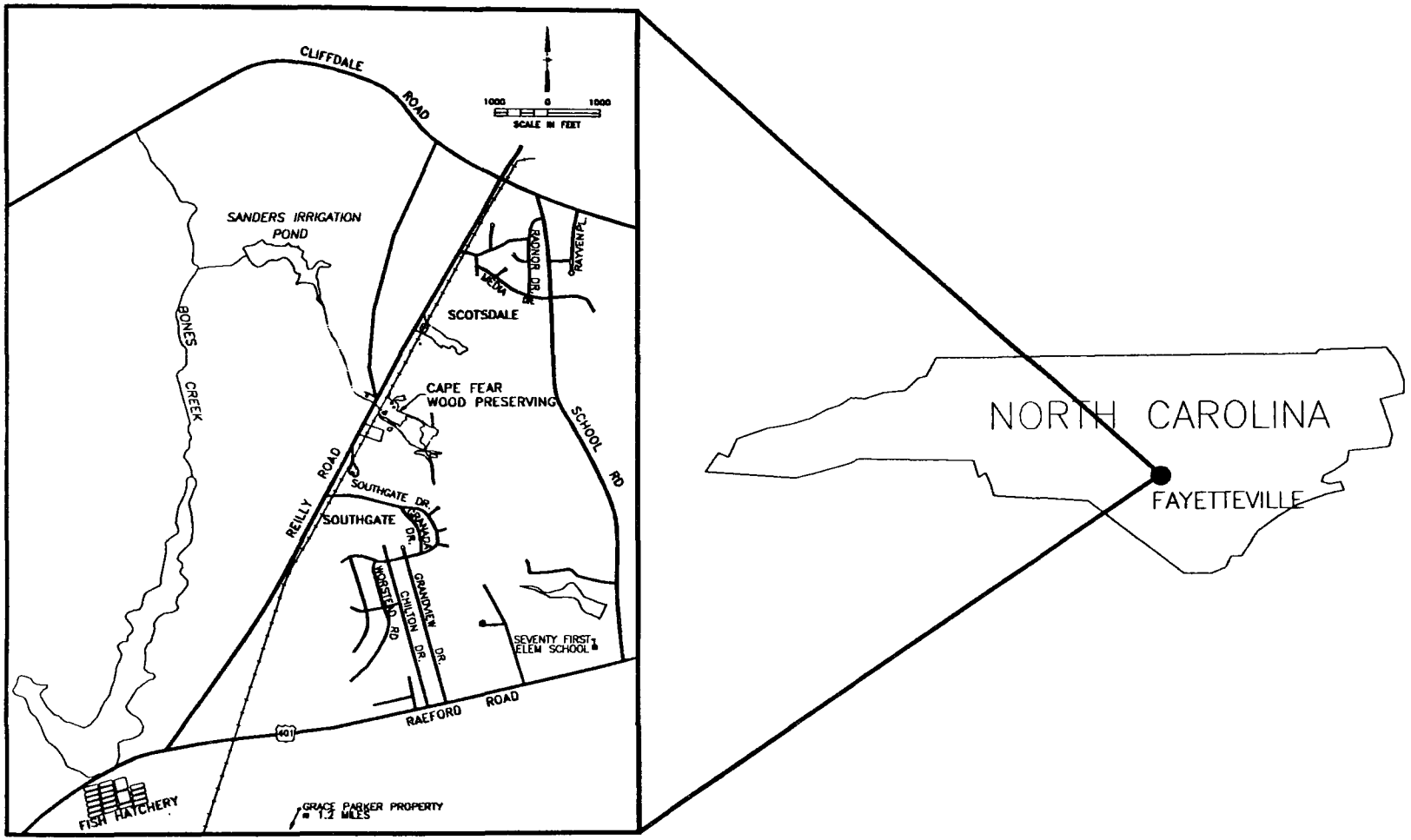

Figure 1 Site Location Map.

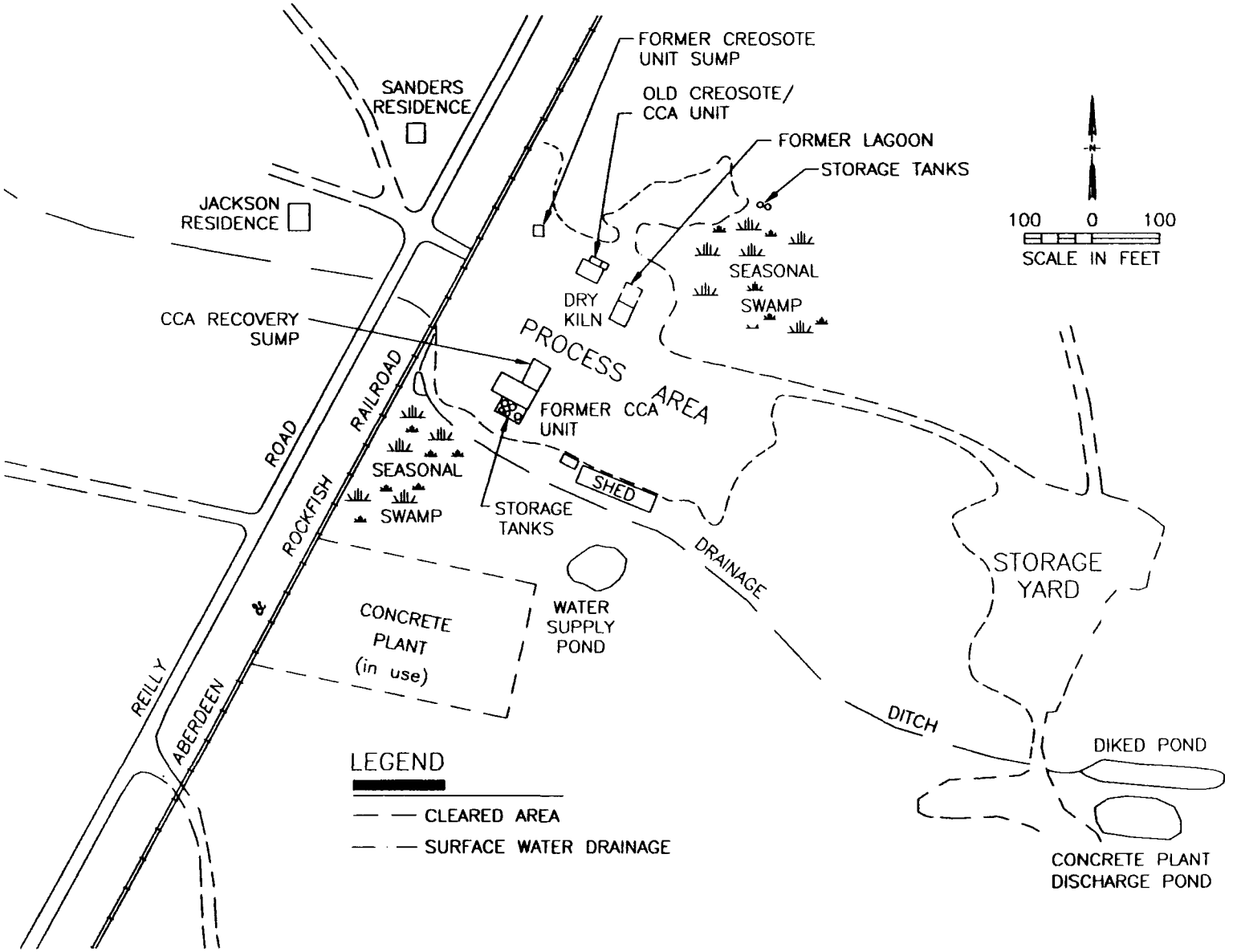

Figure 2 Site Features Map.

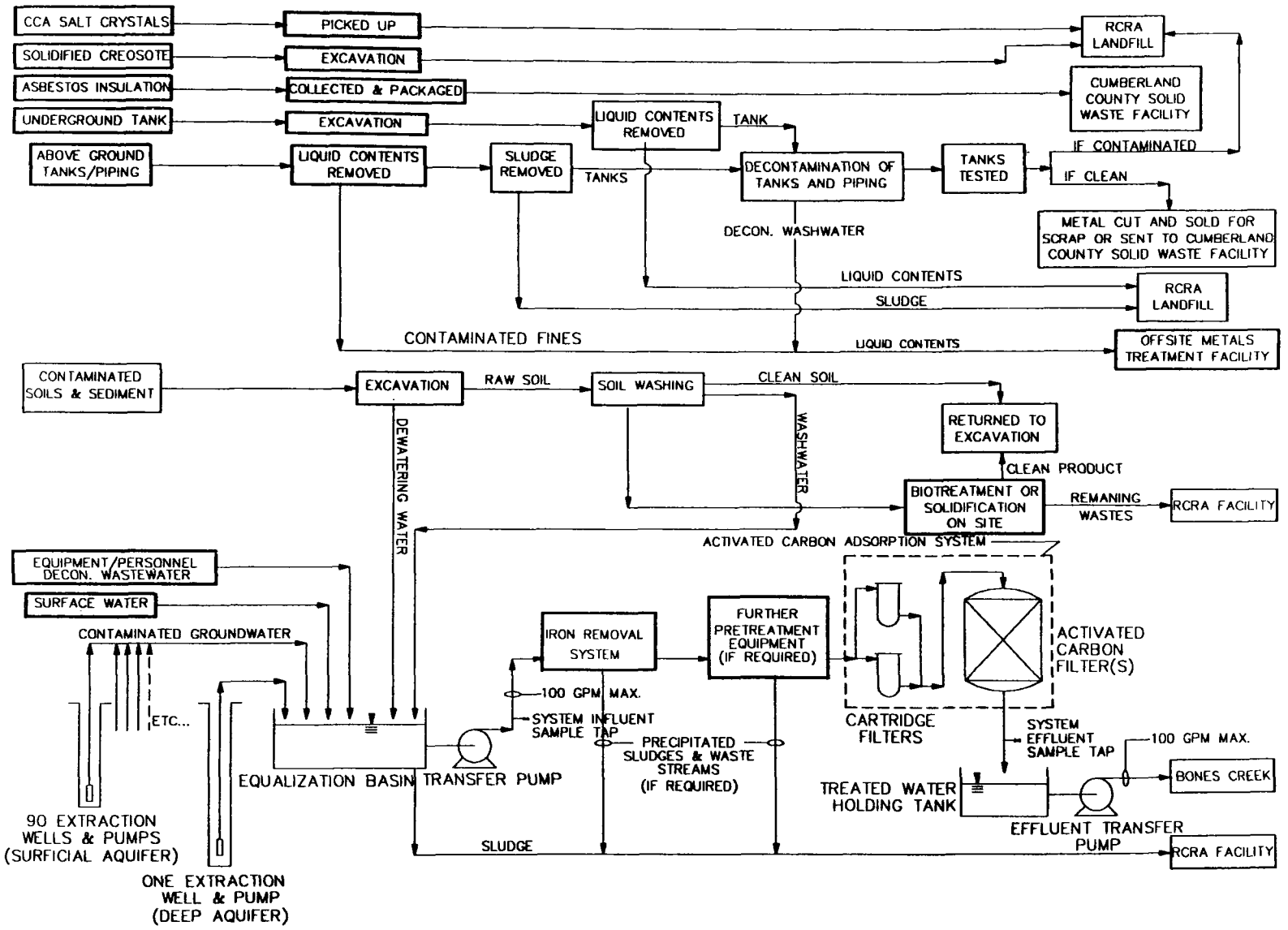

Figure 3 Remedial Design Process Flow Diagram.

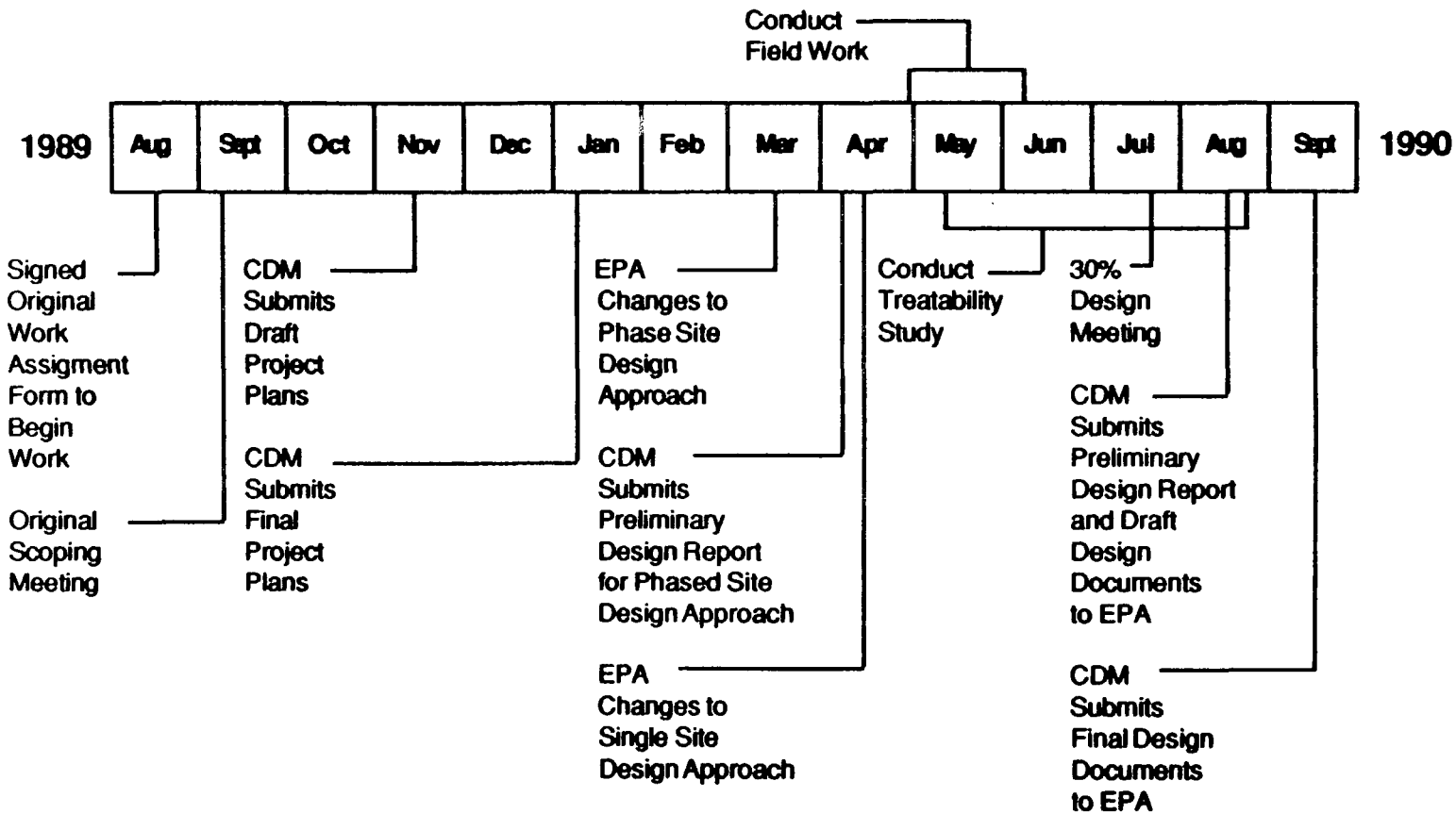

Figure 4 Project Timeline.

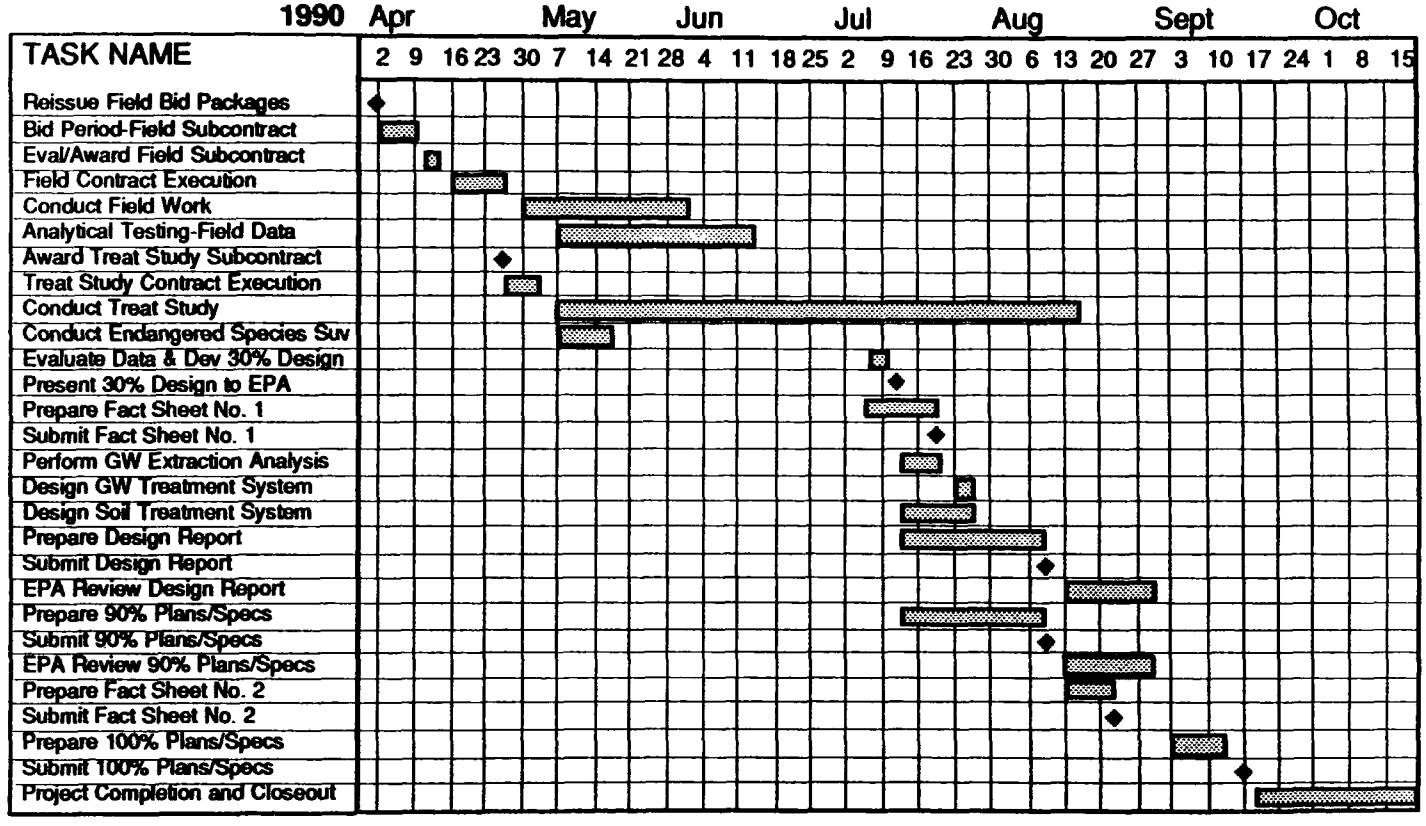

Figure 5 Final Project Schedule.

Table 1 Tasks included in the orginal scope of work (January 1990).

Original Scope of Work

1. Project Planning
2. Field Data Acquisition/Sampling and Analysis
3 Treatability Study - Pilot/Bench Scale Tests
4. Data Evaluation
5. Preliminary Design
6. Intermediate Design
7. Prefinal/Final Design
8. Design Support Activities
9. Value Engineering
10. Community Relations Support
11. Bid Package Preparation
12. Project Completion and Closeout

Table 2 Tasks included in the final scope of work (April 1990).

Final Scope of Work

1. Project Planning
2. Field Data Acquisition/Sampling and Analysis
3. Treatability Study - Bench Scale Test
4. Data Evaluation
5. Preliminary Design - presented at 30% Design Meeting
6. Final Design
7. Design Support Activities
8. Community Relations Support
9. Project Completion and Closeout

Table 3 Fast-Tracking Techniques Used at the Cape Fear Site

Technique	Party Implemented	Applicability to the Cape Fear Project
Reduce design detail	Engineer	Complex design required preparation of plans and specifications. CDM used "performance" type specifications extensively.
Use standardized specifications	Engineer	CDM used previously prepared in-house specifications and modified them for site-specific conditions.
Reuse existing plans	Engineer	CDM conducted the remedial investigation and feasibility study and therefore was able to reuse the Health and Safety Plan, Community Relations Plan, and Quality Assurance Project Plan to expedite remedial design planning.
Provide project continuity	EPA	CDM was selected for the remedial design primarily because of its previous experience with the remedial investigation and feasibility study. This knowledge of the site helped expedite the remedial design.
Expedite site access	EPA	The site is abandoned and the current property owner is cooperative in allowing site access to conduct investigations during the remedial design.
Conduct parallel design reviews	EPA	EPA conducted concurrent design review with the State of North Carolina and the U.S. Army Corps of Engineers.
Keep value engineering study off critical path	None	A value engineering study was eliminated in order to expedite the remedial design.

Ambient Air Quality Management at French Limited Superfund Site

(Author(s) and Address(es) at end of paper)

INTRODUCTION

A subject often overlooked in the design of remediation projects is ambient air impacts of the remediation process. It was, however, recognized early in the remedial investigation phase of the French Limited Superfund project that volatile organic compounds could create ambient air concerns during remediation. As a result, ambient air impacts issues have been considered throughout the preliminary planning and conceptual and final design phases of the French Limited remediation project.

This paper presents the sequence of steps that evolved into the final Ambient Air Management Program at the French Limited site. First, a description of the site and of the early phases of the project are presented. The importance of the cooperative effort between the responsible parties and the U.S. Environmental Protection Agency (EPA) is also discussed. The paper then presents a more detailed description of the in-situ bioremediation demonstration phase of the project that drove the final Ambient Air Management Program. A discussion of the role of risk assessment is presented, followed by details of the air management system to be used during the final remediation activities at the site. It is hoped that the concepts outlined here will serve as a future model for similar sites, enabling air impacts to be more easily addressed at all sites.

BACKGROUND

The French Limited Superfund site located northeast of Houston, Texas, is a former sand pit that is now a 7.3-acre lagoon that contains a 4- to 12-foot layer of petrochemical sludge residue under 12 to 20 feet of water. The sludges were deposited between 1966 and 1972 by French Limited, Inc., a contract waste disposal business permitted by the state of Texas. During its brief operating period, numerous companies used the disposal facility.

Initial remedial investigations were performed by EPA, who placed the site on the Superfund National Priorities List in 1982. A coalition of about 80 companies who used the disposal facilities and were identified by EPA as Potentially Responsible Parties for site remediation formed the French Limited Task Group in 1983. ENSR was contracted by the Task Group to provide a wide range of environmental consulting and engineering services for remediation of the site.

Initial Investigations

The Task Group voluntarily accepted responsibility for proceeding with the site's remedial investigation and feasibility study (RI/FS) under the supervision and oversight of EPA and the Texas Water Commission (TWC). The investigations determined that

the primary hazardous waste problem stemmed from the sludges on the lagoon bottom. While not posing an immediate threat because of the water cover, the site posed a long-term threat to public health and the environment, and remediation was required.

Sampling and analysis of the sludges revealed a broad mixture of petrochemical compounds including a number of EPA priority pollutants. The RI also confirmed that the contamination had migrated into the groundwater. Fortunately, the lagoon is isolated, and adequate time is available for site remediation before contaminant migration becomes a public health threat.

In 1986, the Task Group faced new Superfund regulations emphasizing waste destruction as a preferable remedial alternative. EPA favored incineration as the remedy for the French Limited site.

The chairman of the Task Group's Technical Committee, Richard E. Sloan of ARCO Chemical Company, examined the basis for EPA's incineration preference. He found that EPA had not given serious consideration to biological remediation because no technical database existed to show that the technology could be successfully applied to the French Limited site. Recognizing the potential for cost and time savings using bioremediation, the Task Group obtained EPA approval to perform laboratory studies to determine whether the technology was applicable. Based on positive results from the laboratory studies, further EPA approval was obtained for a large-scale biodegradation field evaluation using 20,000-gallon treatment tanks on the shore of the lagoon. The field evaluation performed in March 1987 again strongly supported the feasibility of applying biological technology at the site.

EPA and TWC held a public meeting to announce that, while incineration was the preferred remediation alternative for the site, based on a request and positive preliminary data from the Task Group, they would authorize a 6-month in-situ biodegradation demonstration before making a final remedial decision.

The in-situ demonstration was successfully completed and the results reported in October 1987.

EPA then completed its review of the technical database and process results achieved during the on-site demonstrations. In a January 1988 public meeting, EPA and TWC reversed their previously announced preference for on-site incineration, and indicated that the biodegradation technology proposed by the French Limited Task Group was the preferred site remedy. After a public comment period, and evaluating all recommendations and comments, EPA signed the Record of Decision for bioremediation at the French Limited site in April 1988.

Ambient air quality management issues are discussed in greater detail for the in-situ bioremediation demonstration and final design program in the remainder of this paper.

PROJECT MANAGEMENT

Special approaches requiring variations of standard industrial wastewater biological treatment were needed due to the characteristics of the sludges and contaminated subsoils. Because the chosen remediation method was a new engineering application that had to be completed within a short timeframe, ENSR developed and established a project management system that emphasized open communication among all parties.

From the beginning, the management approach emphasized open communications regarding all aspects of the project. To ensure that all parties would have adequate review time and to allow opportunities for suggestions and redirection of the project elements, Task Group Chairman Sloan insisted upon immediate data availability to all involved parties, including EPA and TWC.

Daily status review meetings were conducted at the site during the in-situ biodegradation demonstration, providing coordination among Task Group, ENSR, and agency oversight personnel. These meetings maintained daily understanding of project status and progress, and allowed regular definition and resolution of issues and problems as they arose.

The Task Group, ENSR, and EPA regional and oversight staff held weekly meetings during the demonstration to review all technical data obtained during the previous week, and discuss project status. As the technical database and field evaluation evolved, these meetings were used to adjust the direction and details of project activities to ensure that a complete technical database would be available upon completion of the demonstration.

Community Information Program

An important aspect of the immediate and open communication program for the French Limited project was a community information program. This proactive communications program gave all residents in nearby areas the opportunity to hear regular presentations describing the project approach, current status and accomplishments, and final results. The Task Group retained the public relations firm of Goldman & Co. of Houston to manage this important communications link, and coordinate all other aspects of media interest in the project.

Shortly after project initiation, slide presentations of the process operations were presented on a regular basis to community leaders and area groups, as well as to local, state, and federal governmental representatives. Because of the unique nature of

the project, media interest was high, and open communication of the approach and results to the media became another critical component of the program.

The project management and communications approaches were integral to the success of the on-site biodegradation demonstration and EPA's decision to allow bioremediation at the site, and will contribute ultimately to the final cleanup of the site. The approaches created an environment in which issues and ideas, judgment concerns, redirections, and refinements were sought from everyone associated with the project, from regulatory agency and responsible industry parties to independent experts and community residents. This resulted in a continually updated understanding and refinement of project goals and achievements, and allowed prompt and informed conclusions to be reached to the benefit of all concerned (Sloan, 1987).

IN-SITU BIOREMEDIATION DEMONSTRATION

Air issues were considered during the earliest phases of the project, including remedial investigations, laboratory studies, and pilot bioremediation studies. It was during the in-situ bioremediation demonstration that ambient air management became a prominent feature of the overall remediation project. The following discussion describes the monitoring program put in place during this phase of the program.

Based on the preliminary studies at the site, several naturally occurring aerobic bacteria were identified which were thought to show promise as organic biodegraders if their activity could be stimulated and enhanced through the addition of balanced nutrients and oxygen to the system.

A 6-month air monitoring program was one part of the comprehensive environmental monitoring plan associated with the overall bioremediation demonstration project. The environmental monitoring plan encompassed air, groundwater, and health and safety issues. A more comprehensive description of the bioremediation demonstration program can be found elsewhere (Sloan, 1987). The remainder of the discussion will focus on the air issues associated with the site.

The air monitoring program at the site was constructed to respond to concerns of off-gassing of hazardous constituents in the sludge during the addition of oxygen in the form of air sparged into the sludge and lagoon water. The goals of the air monitoring plan for the bioremediation demonstration at the French Limited site were to:

- Measure on-site and site property line impacts of air emissions from the bioremediation processes.

- Protect the health and safety of both on-site personnel and off-site general public.

The resulting data from this phase of the project were also to be used to design the appropriate program for the final remediation option.

Methods

The objectives of the air monitoring program were addressed by monitoring the following five separate groups of variables.

1. Continuous measurement and recording of meteorological data (wind speed, wind direction, temperature, relative humidity, barometric pressure, and precipitation).

2. "Real-time" measurements of total ionizables using photoionization detector (HNu) measurements.

3. "Real-time" syringe sampling for volatiles using on-site gas chromatograph (GC) analysis.

4. "Real-time" sampling of the semi-volatile naphthalene using charcoal absorbent with on-site GC analysis.

5. "Time-integrated" sampling for volatiles by collection on Tenax solid absorbent followed by gas chromatography/mass spectrometry (GC/MS) laboratory analysis.

Three different monitoring levels were used during the course of the project. The most intensive phase (Phase I) was used during the first 3 days of each different operational stage in the bioremediation program (i.e., air sparging, air sparging with sludge pump mixing, and subsoil dredging). A second, slightly lower-intensity phase of monitoring (Phase II) was used after the initial impact of air emissions had been assessed from "real-time" measurements taken during Phase I monitoring. The Phase II level monitoring was better suited to daily routine monitoring throughout lengthy operational stages of the demonstration project. A third, lower-intensity level (Phase III) was begun after Phase II monitoring showed only low levels of air emissions associated with the demonstration project. The Phase II results indicated that air monitoring goals could be accomplished using a lower monitoring intensity.

The sampling frequency and the technical methods employed in each of the three phases of air monitoring are described in the following paragraphs. The use of the term "lagoonside" refers to a sampling location at the edge of the lagoon bank, approximately 5 to 7 feet from the water's edge. The term "fenceline" refers

to a sampling location at the French Limited site property boundary.

Phase I monitoring consisted of:

- Eight-hour, "time-integrated" Tenax samples taken at five locations (one upwind, two downwind lagoonside, two downwind fenceline) each shift, three shifts per day (day, evening, night).

- "Real-time" syringe sampling at three locations (one upwind, one downwind lagoonside, one downwind fenceline) each hour for 8 hours per day.

- "Real-time" naphthalene monitoring each hour at one location (downwind lagoonside) for 8 hours per day.

- "Real-time" total ionizables (e.g., HNu) measurements hourly at the same time and location as each "real-time" syringe sample.

Phase II monitoring consisted of:

- Eight-hour, "time integrated" Tenax samples taken at three locations (one upwind, one downwind lagoonside, one downwind fenceline) once per day.

- "Real-time" syringe sampling taken at three locations (one upwind, one downwind lagoonside, one downwind fenceline) four times per day.

- "Real-time" naphthalene monitoring four times per day at one location (downwind lagoonside).

- Total ionizables (e.g., HNu) measurements at least four times per day at the same time as each "real-time" syringe sample.

Phase III monitoring consisted of:

- Eight-hour, time-weighted-average Tenax samples taken at two locations (upwind and downwind fenceline) each day.

- Total ionizables (e.g., HNu) measurements taken hourly.

Meteorological Measurements

A free-standing 10-meter tower was constructed at the site and used to determine the following meteorological parameters: wind direction, wind speed, temperature, relative humidity, barometric pressure, precipitation, and sigma theta.

Meteorological data from the on-site station were used to locate sampling variations and to correlate air impact data collected with relevant wind conditions.

"Real-Time" Measurements

Three "real-time" measurements were conducted at the site during the demonstration project as a means for daily checks on air impacts within a timeframe to allow for mitigating actions to take place if necessary. These measurements were designed to address air program goals relating to the protection of health and safety of both on-site and off-site personnel, and to develop a database defining instantaneous contaminant concentration levels. The real-time analyses were used by site operations managers in controlling the level of air impacts by reducing and, if necessary, shutting down operations if pre-assigned "action level" concentrations were reached. The real-time measurements included: total ionizables (e.g., HNu) measurements, on-site determination of target volatile organics, and on-site determination of the semi-volatile naphthalene.

Throughout the in-situ biodegradation demonstration, air concentrations were monitored and compared with preset concentration limits. In the real-time impact monitoring program, the concentration levels of seven compounds were monitored, four and eight times per day, in Phase II and Phase I schedules, respectively. These compounds are shown in Table 1 with their 1987 OSHA 8-hour threshold limit values (TLVs) and the action levels that would require reduced intensity of aeration and/or sludge mixing.

Detection of any one of the compounds during the lagoonside sampling at the following concentrations, for the indicated number of samples, required the indicated operating response.

Number of Collected Samples	Concentration	Operating Response
1	TLV	Immediate resample and, if verified, system shutdown.
2	Action Level	Reduced aeration or mixing operation.
4	Action Level	System shutdown.

Target compounds were selected to be representative of expected emissions based on pilot-scale experiments conducted prior to the demonstration project.

TABLE 1

Target Compounds Action Levels

Compound	TLV (ppm)	Lagoonside Action Level (ppm)
Benzene	10.0	5.0
Toluene	200.0	100.0
Ethylbenzene	100.0	50.0
Trichloroethene	100.0	50.0
Tetrachloroethene	100.0	50.0
Chloroform	50.0	25.0
Naphthalene	10.0	5.0

A second curtailment criterion was based upon HNu readings taken at the fenceline sampling locations. A reading in excess of 1.0 ppm above background required immediate reduction in aeration/mixing operations, and, if the 1.0-ppm reading continued for 30 minutes, system shutdown was required.

Volatile Target Compound Monitoring. Real-time volatile target compound monitoring consisted of determination of six organic compounds: chloroform, benzene, trichloroethene, toluene, tetrachloroethene, and ethylbenzene. These compounds were selected based on emissions characterized from laboratory and pilot studies on the lagoon sludge. Two GCs equipped with photoionization detectors (Photovac 10S50) were used for the target compound determinations. These chromatographs were located in the field laboratory, where the samples were analyzed and data reduced on-site. Grab samples were collected manually using 1.0-ml gas-tight syringes. Samples were taken directly to the field laboratory for analysis.

The specific sampling locations (upwind and downwind) selected for each sampling event were based upon the meteorological conditions existing at the time. Each sample was collected from one of 36 pre-selected sampling stations shown in Figure 1. The specific sampling location was selected to be nearest to the then-current wind direction.

All GC data were reduced on-site and the results were posted on a central data board located in the field operations office. Quality assurance procedures included collection of blanks and collocated samples. Calibrations for the six target compounds were conducted at least twice daily from a certified gas mixture of each component.

Naphthalene Monitoring. Naphthalene is the most volatile of the polynuclear aromatic (PNA) compounds and was known to be present in the lagoon sludge. As such, naphthalene was identified as the PNA most likely to be released during the demonstration project.

NIOSH analysis Method 1501 for aromatic hydrocarbons, used for determination of naphthalene analysis, was performed in the field laboratory using a GC (Hewlett Packard 5990) equipped with a flame ionization detector. Charcoal absorbent tubes were used for absorption of naphthalene from air sampled by a calibrated battery-operated air sampling pump. The time period for sampling was generally 1 hour.

The specific sampling locations were selected based upon the meteorological conditions at the time of sampling. Each sample was collected from whichever of the 36 pre-selected stations was closest to the predicted one-hour wind direction. All naphthalene data were reduced on-site and results posted on the

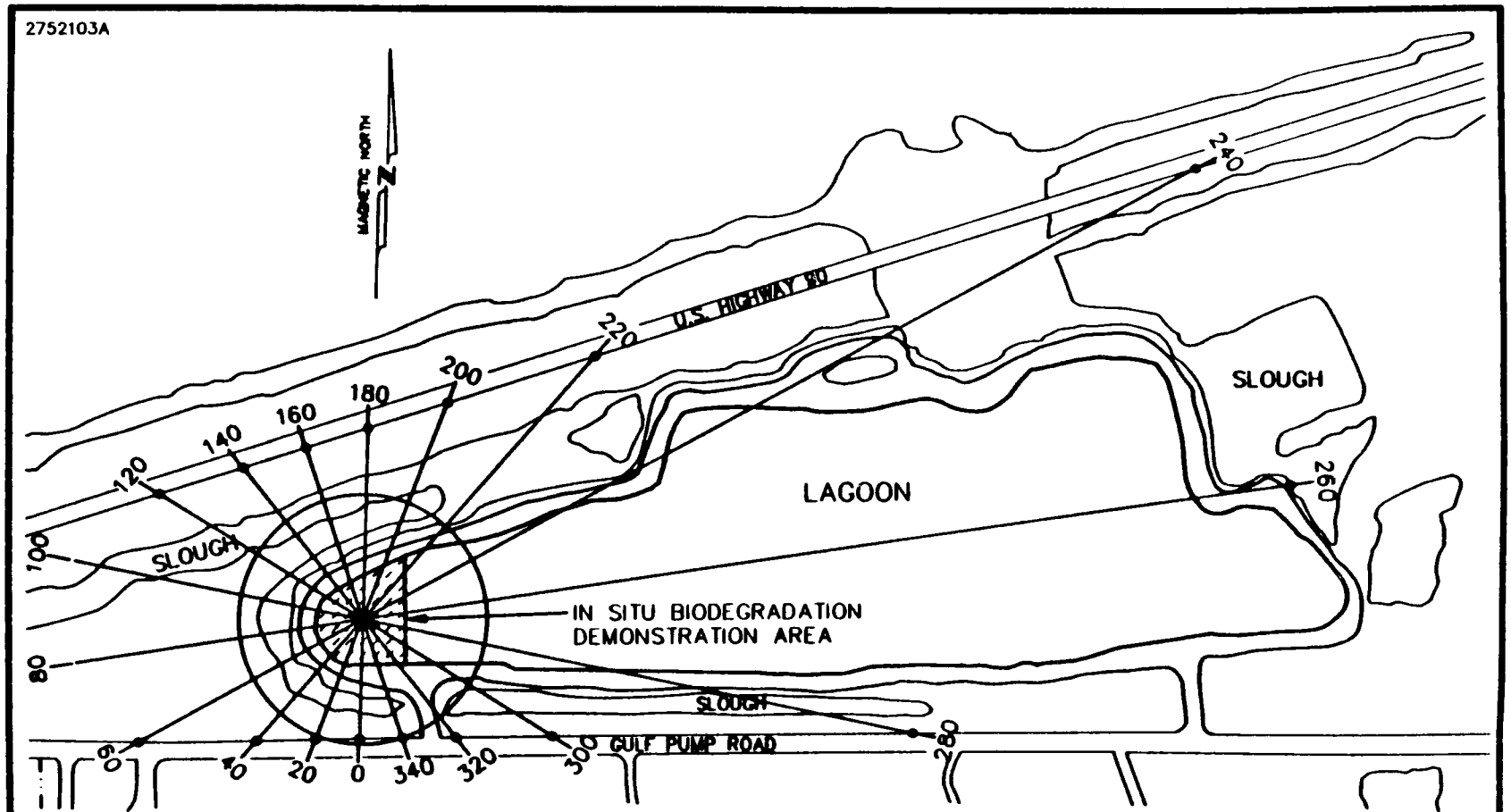

FIGURE 1

LEGEND

● – AIR SAMPLING LOCATION

200 0 200

SCALE IN FEET

ENSR™

ENSR CONSULTING AND ENGINEERING

FRENCH LIMITED
BIODEGRADATION DEMONSTRATION
AIR SAMPLING LOCATIONS

DRAWN: JDG	DATE: 3/14/91	PROJECT NUMBER: 2870-014	REV.
APPV'D:	REVISED:		

central data board, located in the field operations office. Calibrations using prepared solutions of naphthalene were conducted at least daily. Quality assurance procedures included field and laboratory blanks, spikes, and collocated samples.

Total Ionizables Measurements. A total ionizables measurement using an HNu photoionization detector was made and recorded at the same time and at the same location at which each syringe sample was taken. The HNu was calibrated with a certified standard of isobutylene at least daily.

Time-Integrated Sampling For HSL Volatiles

The time-integrated monitoring was conducted at the site during the demonstration to document the average daily impact on downwind areas on-site and at fenceline locations.

Time-integrated impact measurement samples were collected by drawing the air sample through a cartridge of pre-cleaned Tenax solid sorbent material. The sample was drawn through the Tenax tube at a measured flow rate using a battery-operated air sampling pump. The time period of sampling was generally 8 hours. Samples were packaged in accordance with EPA-approved QA/QC procedures and forwarded to an off-site laboratory for analysis. There, the samples were thermally desorbed from a heated chamber onto a GC column for GC/MS analysis.

The GC/MS analysis of the sample determined the concentration levels of the 35 volatile organic compounds from the EPA Hazardous Substance List (HSL). The HSL was used because it represented those constituents that might be expected to evolve from the process operations based on air contaminant measurements from the earlier-conducted pilot-scale experiments.

In addition to the routine analysis for the HSL, 12 selected ambient air Tenax samples were analyzed qualitatively to identify the predominant compounds collected, without regard to a specific target list.

The specific locations of upwind and downwind sampling were based on the meteorological conditions existing at the time. Each sample was collected from whichever of the 36 pre-selected sampling stations was nearest to the 8-hour predicted downwind (or upwind) direction.

Quality assurance procedures included daily field and laboratory blanks, spikes, and collocated sampling. GC/MS analytical procedures followed EPA Methods (TO-1).

Results

The monitoring programs described above were carried out according to Phase I, II, and III schedules on the following dates in 1987:

- Phase I 4/21 to 4/23
- Phase II 4/24 to 5/11
- Phase I 5/12 to 5/14
- Phase II 5/15 to 8/25
- Phase I 8/25 to 8/28
- Phase II 8/29 to 9/2
- Phase I 9/3 to 9/4
- Phase III 9/5 to 10/9

The dates identified are helpful in understanding the results described below.

Total Ionizables Results

More than 1,800 individual total ionizables measurements were made throughout the air program scheduled readings. In addition, HNu measurements were made continuously at downwind fenceline locations during actual sludge mixing or soil dredging to monitor for action level concentrations. The highest HNu measurement recorded was 9.5 ppm at lagoonside and 1.8 ppm at fenceline.

On two occasions, operations were curtailed due to HNu readings exceeding the action limit of 1.0 ppm above background. In both cases, sludge aeration and mixing activities were curtailed and the fenceline readings returned to below the action limit within 20 minutes, and did not exceed the limit during the rest of the day. Sludge mixing was started again the next day without HNu readings exceeding action limits.

Procedures required on-site personnel to wear organic vapor cartridge-type respirators when HNu readings exceeded 1.0 ppm above background. The occasions when this was needed were few and generally of short duration.

"Real-Time" Target Volatiles Results

Over 1,800 syringe-collected samples were analyzed for the six target volatile compounds. Table 2 presents the summary results of the monitoring. The concentrations of all target compounds remained well below their action limits for the entire demonstration project. The single highest percent of an action limit was for benzene, and was only 3% of the limit at the fenceline. There was never a need to curtail operations due to target compound concentrations levels.

TABLE 2

FRENCH LIMITED BIODEGRADATION DEMONSTRATION
REAL-TIME TARGET VOLATILES RESULTS SUMMARY
Concentration in Parts Per Billion (ppb)

Target Compound	TLV	Action Limit	Detection Limit	Lagoonside Concentration Range	Lagoonside Maximum Concentration % of Action Limit	Fenceline Concentration Range	Fenceline Maximum Concentration % of Action Limit
Chloroform	50,000	25,000	350	BDL	——	BDL	——
Benzene	10,000	5,000	10	BDL-1160	23	BDL-150	3.0
Trichloroethene	100,000	50,000	10	BDL-675	1.4	BDL-520	1.0
Toluene	200,000	100,000	25	BDL-1494	1.5	BDL-590	0.6
Tetrachloro-ethene	100,000	50,000	30	BDL-850	1.7	BDL-156	0.3
Ethylbenzene	100,000	50,000	50	BDL-810	1.6	BDL-420	0.9

BDL - Below Detection Limit

Naphthalene Results

Over 600 on-site determinations for naphthalene were made during the monitoring program. No naphthalene was detected during the ambient monitoring above the method detection limit of 150 ppb. Therefore, throughout the program, all samples contained less than 3% of the naphthalene action limit of 5 ppm.

Time-Integrated Sampling Results

Qualitative Time-Integrated Results. Twelve Tenax samples analyzed during the program were selected for qualitative identification of all major compounds present. Figure 2 presents a typical total ion chromatogram from the GC/MS analysis. Each of the major peaks in the chromatogram is identified. The compounds identified were either simple hydrocarbons or compounds on the HSL list.

These qualitative results indicate that the HSL target compounds provide a good characterization of the potentially hazardous constituents present in the air emissions.

Quantitative Time-Integrated Results. Over 1,500 Tenax samples were analyzed during the program period. Table 3 summarizes the results for quantitative time-integrated determinations. As can be seen from Table 3, trans-1,2-dichloroethene had the highest lagoonside 8-hour average concentrations of any of the HSL compounds. However, this concentration represented only 0.2% of its TLV.

Concentrations determined for fenceline locations were even lower, with 30 of the 35 compounds determined to be normally below detection limits.

Comparison of Results

The air program had to be comprehensive in the variety of compounds it tested for, yet responsive enough to feed back information quickly, in order to meet project objectives.

Real-time or continuous measurements (using equipment such as photoionization or flame ionization detectors) for organic air pollutants, give immediate results, but are not compound-specific and generally have relatively high detection limits (in the parts-per-million range). Detection limits, more applicable to ambient measurements in the parts-per-billion or even sub-ppb range, can be achieved through concentrating a large volume of air contaminants on sorbents. These samples can also be sent to laboratories for sophisticated analyses such as GC/MS. These results are, by nature, historical; by the time the analysis is complete, the composition of the ambient air may be much different.

FIGURE 2

FRENCH LIMITED BIODEGRADATION DEMONSTRATION
FLUX CHAMBER RESULTS GC/MS DATA

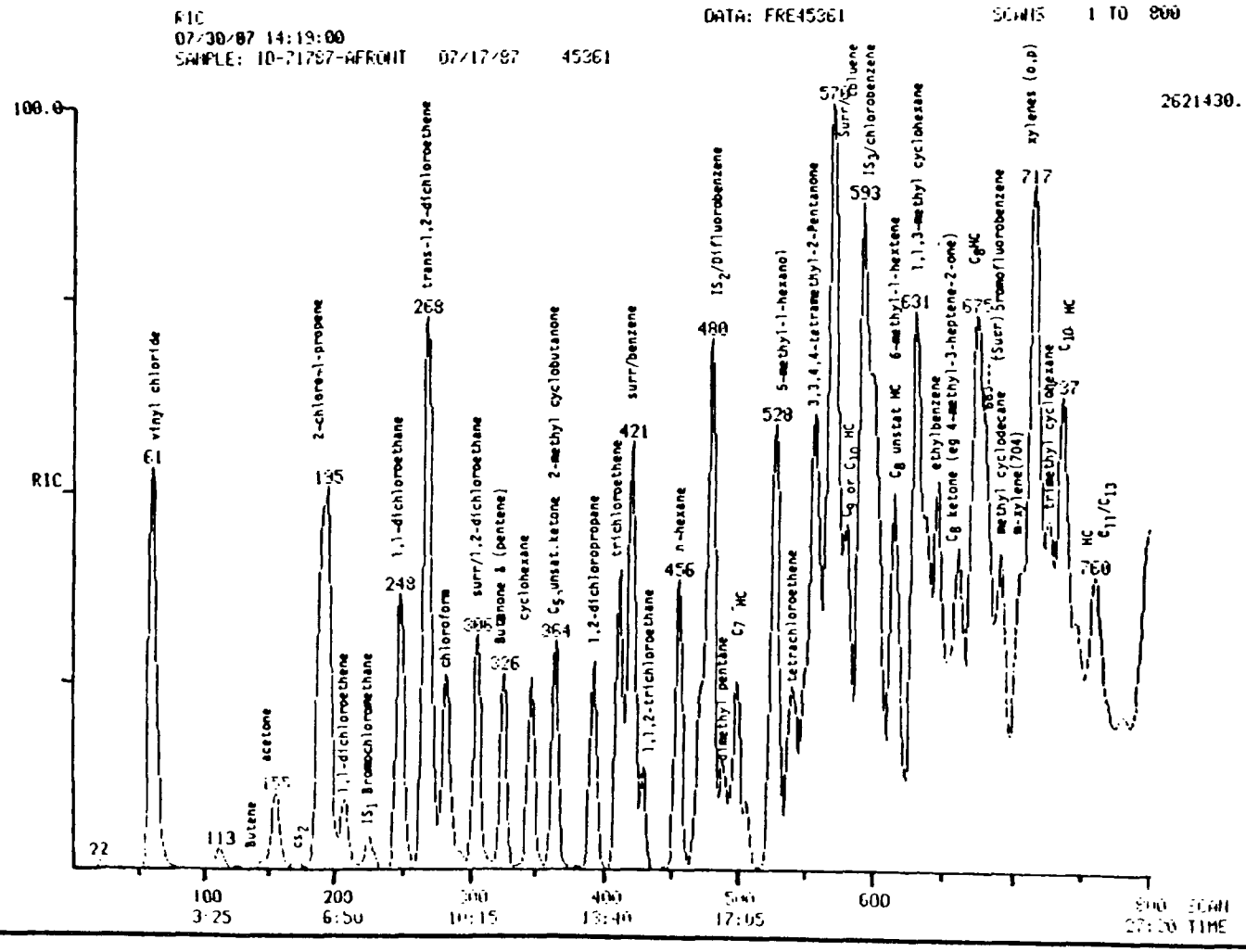

TABLE 3

FRENCH LIMITED BIODEGRADATION DEMONSTRATION
TIME-INTEGRATED IMPACT MONITORING RESULTS SUMMARY
Concentration in Parts Per Billion (ppb)

			Lagoonside			Fenceline	
Compound	TLV	Detection Limit[1]	Actual Concentration Range[2]	Highest Concentration % of TLV	Most Frequent Concentration Range[3]	Actual Concentration Range[2]	Most Frequent Concentration Range[3]
Choloromethane	50,000	0.6	BDL-2.4	0.005	BDL	BDL	BDL
Bromomethane	5,000	0.3	BDL	-	BDL	BDL	BDL
Vinyl Chloride	5,000	0.4	BDL-132	3	BDL	BDL-1.8	BDL
Chloroethane	1,000,000	0.4	BDL	-	BDL	BDL	BDL
Methylene Chloride	50,000	0.3	BDL-7.7	0.015	BDL	BDL-3.9	BDL
Acetone	750,000	0.5	BDL-46	0.006	BDL-10	BDL-31.1	BDL-10
Carbon Disulfide	10,000	0.4	BDL-134	1	BDL	BDL-56	BDL
1,1-Dichloroethene	5,000	0.3	BDL-3.5	0.7	BDL	BDL	BDL
1,1-Dichloroethane	200,000	0.3	BDL-225	0.1	BDL-10	BDL-5.9	BDL
Trans-1,2-Dichloro-ethene	200,000	0.3	BDL-483	0.24	10-50	BDL-16	BDL
Chloroform	10,000	0.2	BDL-9.4	0.009	BDL-10	BDL-3.4	BDL
1,2-Dichloroethane	10,000	0.3	BDL-214	2	BDL-10	BDL-9.6	BDL
2-Butanone	200,000	0.4	BDL-122	0.06	BDL-10	BDL-61.4	BDL
1,1,1-Trichloroethane	350,000	0.2	BDL-1.4	0.0004	BDL	BDL-0.5	BDL
Carbon Tetrachloride	5,000	0.2	BDL-1.1	0.02	BDL	BDL-1.1	BDL
Vinyl Acetate	10,000	0.3	BDL-9.8	0.1	BDL	BDL-1.0	BDL
Bromodichloroethane		0.2	BDL	-	BDL	BDL	BDL
1,2-Dichloropropane	75,000	0.2	BDL-110	0.15	BDL-10	BDL-2.0	BDL
Trans-1,3-Dichloro-propene	1,000	0.3	BDL	-	BDL	BDL	BDL
Trichloroethene	50,000	0.2	BDL-88	0.18	BDL-10	BDL-1.2	BDL
Dibromochloromethane		0.1	BDL	-	BDL	BDL	BDL

Notes:

1. Based on normal 20-liter air volume.
2. BDL entries indicate levels were below detection limits.
3. Concentration level ranges used: BDL, BDL-10 ppb, 10-50 ppb, >50 ppb.

TABLE 3 (continued)

FRENCH LIMITED BIODEGRADATION DEMONSTRATION
TIME-INTEGRATED IMPACT MONITORING RESULTS SUMMARY
Concentration in Parts Per Billion (ppb)

			Lagoonside			Fenceline	
Compound	TLV	Detection Limit[1]	Actual Concentration Range[2]	Highest Concentration % of TLV	Most Frequent Concentration Range[3]	Actual Concentration Range[2]	Most Frequent Concentration Range[3]
1,1,2-Trichloroethane	10,000	0.2	BDL-11.2	0.11	BDL	BDL-1.1	BDL
Benzene	10,000	0.4	BDL-255	3	BDL-10	BDL-11	BDL-10
Cis-1,3-Dichloro-propene	1,000	0.3	BDL	-	BDL	BDL	BDL
2-Chloroethyl Vinyl Ether		0.3	BDL-3.8	-	BDL	BDL	BDL
Bromoform	500	0.1	BDL	-	BDL	BDL	BDL
2-Hexanone	5,000	0.3	BDL-1.3	0.02	BDL	BDL	BDL
4-Methyl-2-Pentanone	50,000	0.3	BDL-3.7	0.007	BDL	BDL	BDL
Tetrachloroethene	50,000	0.2	BDL-6.1	0.01	BDL	BDL-0.2	BDL
1,1,2,2-Tetrachloro-ethane	1,000	0.2	BDL	-	BDL	BDL	BDL
Toluene	100,000	0.3	BDL-121	0.1	BDL-10	BDL-24	BDL-10
Chlorobenzene	75,000	0.2	BDL-19.8	0.025	BDL	BDL-1.0	BDL
Ethylbenzene	100,000	0.3	BDL-152	0.1	BDL-10	BDL-5.8	BDL-10
Styrene	50,000	0.3	BDL-52.9	0.1	BDL	BDL-1.1	BDL
Total Xylene	100,000	0.3	BDL-112	0.1	BDL-10	BDL-7.0	BDL-10

Notes:

1. Based on normal 20-liter air volume.
2. BDL entries indicate levels were below detection limits.
3. Concentration level ranges used: BDL, BDL-10 ppb, 10-50 ppb, >50 ppb.

The air monitoring project developed for the French Limited project incorporated the real-time measurements, qualitative and quantitative time-integrated measurements, and intermediate "grab" samples analyzed on-site with minimal turnaround time.

Which method was best for the study? All the applied methods had their place in accomplishing the goals of the project.

Table 4 presents the applications, benefits, and limitations of the three air monitoring approaches used.

Based on these results and the comparison of techniques described above, air monitoring successfully accomplished its goals of protecting the health and safety of on-site and off-site personnel and documenting the contaminants released by the bioremediation demonstration.

Results

Air impacts during the in-situ bioremediation demonstration were minimal and placed few limitations on day-to-day operations because the air monitoring program allowed answers to air impact questions to be available in time to ensure proper and safe site operations. When impacts did occur, they were found to be readily controllable, decreasing immediately upon reducing the intensity of sludge aeration or mixing.

EQUIPMENT DEVELOPMENT

Upon completion of the in-situ bioremediation demonstration phase of the project, an equipment development phase was begun. During this phase, various pieces of equipment, including aerators, mixers, pumping systems, etc., were tested for applicability for use in the final remediations. A new cell of the lagoon was walled off next to the in-situ demonstration cell. An additional cell was also walled off at the east end of the lagoon for testing during this phase as well. The testing of equipment proceeded during the next approximately 1-1/2 years.

Because this testing of mixing and aeration activities had the potential for ambient air impacts, air monitoring efforts were continued during this phase of the program. Time-weighted-average Tenax measurements were taken on a daily to weekly basis depending on the level of activity at the site. All measurement results were compiled and reported with the monthly progress reports describing the operational activities at the site.

Results during this phase of the operation showed no significant ambient air impacts resulting from equipment development. These results, in combination with the results

TABLE 4

Approach	Application	Benefit	Limitation
Real-time HNu/OVA	Short-term impact monitoring for health & safety.	Most sensitive action limit trigger for project.	No compound-specific information possible. Only semi-quantitative
Syringe Grab Samples	Short-term impact monitoring for health & safety.	Limited compound-specific information possible. Peak values measured. Qualitative results available immediately.	Only six compounds measured. Labor intensive.
Time-Integrated Tenax Samples	8-hour time-integrated impacts for volatiles	Compound-specific for large variety of contaminants. Good qualitative and quantitative results.	Long-term-average impacts only. Longest turnaround time for results.

from the in-situ bioremediation demonstration phase, represent one of, if not the most, comprehensive long-term ambient air databases developed for any Superfund site.

REMEDIAL ACTION PLAN

Ambient air management was a key element in the development of the Remedial Action Plan (RAP) for the French Limited site. It was decided by the management team that the best strategy for accomplishing the goals of the remediation while minimizing air impacts was to base the air management program on a risk assessment evaluation. A risk assessment was conducted for the bioremediation demonstration project to determine whether the emissions anticipated during the full-scale final bioremediation effort would be acceptable. Air monitoring techniques were established in the RAP that would produce the data necessary for ongoing evaluation of risk during the final remediation. The monitoring techniques have been more fully developed and presented in the final air monitoring program design, and are discussed in detail following a description of the risk assessment procedures used.

Risk Assessment On Bioremediation Demonstration Project

CERCLA Section 121 requires that the clean-up remedies applied in the remediation of a Superfund site must be protective of human health and the environment. Using the measurements collected in the air monitoring program (described above), a human health risk assessment was conducted to assess the potential health risks to nearby residents from exposure to lagoon emissions during bioremediation activities. The following discussion describes the procedures and results of the risk assessment evaluation on the bioremediation demonstration project.

Hazard Identification

The data produced by the air monitoring program indicated that the majority of the lagoon emissions during the bioremediation demonstration project were relatively non-toxic chemicals, such as aliphatic hydrocarbons. However, 33 of the 35 volatile organic compounds (VOCs) on the HSL were also identified in small quantities. Due to their potential toxicities, these 35 compounds were evaluated in the human health risk assessment. The air monitoring data were examined for compound concentration, trends in distribution, and consistency of detection for these 35 VOCs. The VOC releases were found to be discontinuous and variable over the course of the demonstration project, due to the uneven distribution of the chemicals in the lagoon and variations in the bioremediation operations. It was concluded that the particular chemicals that may be released and the concentrations

of those chemicals will vary throughout the full-scale bioremediation project.

Exposure Assessment

The potential exposure pathway evaluated in the risk assessment was the inhalation of gaseous compounds emitted from the lagoon during the bioremediation demonstration. Other exposure pathways were considered to be not applicable because access to the site is prevented and the groundwater is not utilized as a drinking water source. Exposure point concentrations in the ambient air were modeled for the nearest receptors, i.e., the closest residents downwind of the lagoon site. The modeled receptor locations were located in the Riverdale subdivision approximately 675 feet to the west-southwest of the lagoon (identified as receptor #1), and in the Dreamland subdivision approximately 2,900 feet to the east-southeast of the lagoon (identified as receptor #2). Receptors #1 and #2 represented the people located nearest the lagoon, who have the highest potential exposure and any associated health risk. People living farther away from the site and people occasionally passing through the area would have lower exposures and, thus, fewer risks.

Potential chronic inhalation exposure was estimated for these receptors using a standard risk assessment equation for average daily dose.

Average Daily Dose (mg/kg/day) = Air concentration (mg/m^3) x Inhalation rate (m^3/person/day) x 1/body weight (person/kg)

To estimate the average daily dose, the concentration of each compound in the air at the point of exposure was modeled using the long-term average concentration measured by the Tenax monitoring technique. The inhalation rate and body weight were assumed to be 20 m^3/day and 70 kg, respectively, as is typically assumed by the EPA (EPA, 1989).

The potential for long-term adverse health effects at receptors #1 and #2 was evaluated by estimating the average daily doses and any associated chronic carcinogenic and noncarcinogenic risks. The potential for short-term adverse health effects at receptors #1 and #2 was evaluated by comparing the modeled maximum 8-hour average air concentration to an allowable air concentration for each chemical.

Dose-Response Assessment

The toxicity of each of the 35 HSL compounds was reviewed with regard to both acute (short-term) and chronic (long-term) health effects. An acute effect occurs in response to a brief

exposure usually to a higher concentration of a compound than might result in chronic effects. A chronic effect occurs in response to extended exposure to a relatively low concentration of a compound. Chronic health effects may be manifested as the development of cancer or the development of noncarcinogenic effects such as the impairment of liver or lung function. The toxicity literature and EPA dose-response databases were reviewed to obtain quantifiable estimates of acute and chronic health effects.

Acute Health Effects. The severity of acute effects depends on the exposure concentration; that is, higher concentrations may produce severe, irreversible effects, while lower concentrations may cause limited, reversible effects. In general, the focus of health-protective guidelines is the prevention of relatively low-level, readily reversible effects, such as coughing or eye irritation.

In this risk assessment, the "allowable air concentration" was designated as the threshold limit value -- time-weighted average (TLV-TWA) divided by an uncertainty factor. The TLV-TWA values are listed by the American Conference of Governmental Industrial Hygienists (ACGIH) and represent the TWA concentration for an 8-hour workday and 40-hour work week to which workers may be repeatedly exposed without experiencing adverse health effects. The allowable air concentrations were derived by dividing the TLV-TWA by an uncertainty factor of 42. This uncertainty factor was derived by multiplying a factor of 4.2 (to adjust the 8-hour, 5-day TLV-TWA to an allowable concentration appropriate for the 24-hour, 7-day exposure anticipated in this risk assessment) by factor of 10 (to account for possible sensitive individuals in the exposed population).

Chronic Noncarcinogenic Health Effects. Acceptable exposure levels for noncarcinogenic health effects are based on the existence of no-effect thresholds, i.e., levels below which exposures are unlikely to cause adverse effects. When exposed to levels below the threshold, the human body is able to detoxify the chemical or otherwise adjust to compensate for any potential adverse physiological effects. Exposure limits for chemicals with no-effect thresholds are called reference doses (RfDs) or inhalation reference concentrations (RfCs). RfDs and RfCs are dose-response values based on the assumed no-effect threshold, derived from either human or animal data, combined with appropriate uncertainty factors. RfDs are expressed as doses in milligrams chemical per kilogram body weight per day (mg/kg/day). RfCs are similar to RfDs, but are expressed as concentrations in units of milligrams chemical per cubic meter of air (mg/m^3). A person exposed to a dose (concentration) which is less than the RfD (RfC) is assumed to experience no adverse health effects from the exposure.

The RfDs and RfCs used in this risk assessment were obtained from the EPA Integrated Risk Information System (IRIS) database (EPA, 1990a) and the Health Effects Assessment Summary Tables (HEAST) (EPA, 1990b).

Chronic Carcinogenic Health Effects. It is assumed, for regulatory purposes, that the development of cancer does not exhibit a no-effect threshold, meaning that every exposure to a potentially carcinogenic chemical is assumed to pose some risk. However, there is increasing recognition that thresholds exist below which some chemicals do not cause cancer. This is especially true for several of the chlorinated hydrocarbons listed on the HSL. Nonetheless, the assumption of no-threshold is conservatively applied in this project. The no-threshold approach for assessing cancer risk implies that the cumulative exposure up to any given point of time determines the cancer risk at that time, regardless of any variability in exposure concentrations over shorter time periods.

EPA quantifies cancer risk by applying a linearized multistage model to available data, obtained either from humans or experimental animals, to derive a cancer slope factor (CSF). The CSF derived from animal studies reflects a nearly uniform dosing regimen administered throughout an animal's lifetime. The CSF is expressed in units of $(mg/kg/day)^{-1}$. The CSF values used in this risk assessment were obtained from the IRIS database (EPA, 1990a) and HEAST (EPA, 1990b).

Risk Characterization

Risk characterization is the process in which the dose-response information is combined with the estimated exposure data for the chemicals identified as being potentially hazardous. The result is an estimate of the likelihood that people exposed to the chemicals will experience acute or chronic health effects, given the assumptions used in the risk assessment.

Acute Health Risks. The acute health risks from exposure to compounds emitted from the lagoon during the demonstration project were assessed by calculating a short-term effect ratio. This ratio compared the modeled maximum 8-hour average air concentrations at receptors #1 and #2 with the adjusted TLVs, which were considered to be "allowable air concentrations," as shown below.

$$\underset{(unitless)}{Short\text{-}Term\ Effect\ Ratio} = \frac{Short\text{-}Term\ Maximum\ Air\ Concentration\ (ppb)}{Adjusted\ TLV\ (ppb)}$$

If the short-term effect ratio is less than 1, the allowable short-term air concentration is not exceeded and no short-term health effects would be expected to occur. If the short-term effect ratio is greater than 1, then the allowable short-term air concentration is exceeded, and a potential for adverse short-term health effects may exist. The potential for short-term health effects from inhalation exposure was evaluated for receptor locations #1 and #2 for the 32 HSL compounds for which TLV data exist.

At both receptor locations #1 and #2 for all 32 compounds, the short-term effect ratio was less than 1 by one to six orders of magnitude. Thus, it was concluded that no adverse short-term health effects occurred at the nearest residential receptor locations during the bioremediation demonstration project.

Chronic Noncarcinogenic Risks. To estimate potential noncarcinogenic risks associated with a given level of chemical exposure, a hazard index was calculated. The equation for computing the hazard index is shown below.

$$\textit{Hazard Index (unitless)} = \frac{\textit{Average Daily Dose (mg/kg/day)}}{\textit{RfD (mg/kg/day)}}$$

If the hazard index is less than 1, the RfD is not exceeded and no adverse noncarcinogenic health effects would be expected to occur. If the hazard index is greater than 1, the RfD is exceeded and a potential for adverse noncarcinogenic health effects may exist.

Noncarcinogenic health effects from inhalation exposure were evaluated at receptor locations #1 and #2 for the 16 HSL compounds for which RfDs were available. For each of the 16 compounds, the hazard index was less than 1 by two to five orders of magnitude. The total hazard index was also less than 1.0 at both receptor locations.

Chronic Carcinogenic Risks. To estimate potential carcinogenic risks associated with a given level of chemical exposure, an excess lifetime cancer risk was calculated. The computed excess lifetime cancer risk is an estimate of the upper 95% confidence level on the increased chance of contracting cancer, above background cancer rates. The equation for computing the excess lifetime cancer risk is shown below.

$$\text{Excess Lifetime Cancer Risk (unitless)} = \text{Average Daily Dose (mg/kg/day)} \times \text{CSF (mg/kg/day)}^{-1} \times \text{Lifetime Averaging Factor (year/year)}$$

Standard risk assessment practice specifies that a less-than-lifetime exposure must be averaged over a 70-year lifetime in the calculation of carcinogenic effects (EPA, 1989). The lifetime averaging factor for calculating carcinogenic effects equals the elapsed exposure period divided by the assumed 70-year lifetime. Because the bioremediation demonstration project lasted approximately 2 years, the lifetime averaging factor for estimating carcinogenic effects in this risk assessment was 2 years divided by 70 years.

The excess lifetime cancer risk is typically compared with levels of cancer risk that are considered allowable or acceptable. EPA defines the acceptable range in excess lifetime cancer risk to be between 1×10^{-4} and 1×10^{-6} (EPA, 1990c).

Carcinogenic health effects from inhalation exposure were evaluated at both receptor locations #1 and #2 for the 15 HSL compounds for which CSFs are available. For each of the 15 compounds, the excess lifetime cancer risks were 2×10^{-6} (2 in 1 million) or lower. The total carcinogenic risk was 6×10^{-6} (6 in a million) at receptor #1 and 8×10^{-7} (8 in 10 million) at receptor #2. These levels are within the limits defined as acceptable by EPA. These levels are so low that they would not be detectable given an average background rate of about one in three for contracting cancer.

Results

The results of the risk assessment on the bioremediation demonstration project showed that the lagoon emissions during remediation were well below levels likely to cause acute or chronic adverse health effects. On the basis of this risk assessment it was concluded that it would be possible to conduct the full-scale bioremediation effort within the constraints of emission limitations that would protect human health.

AMBIENT AIR QUALITY MANAGEMENT PROGRAM FINAL DESIGN

Development of Health-Protective Emission Limits

Because of the variable nature of the lagoon emissions during the remediation process and the potential toxicity of some of the VOCs emitted from the lagoon, it was recognized that the potential risks to human health would be a major controlling factor over the full-scale bioremediation project. The bioremediation operation would have to be managed to limit

potential risks to human health by limiting air emissions. For this purpose, emission limitations were established based on health risk criteria, which were approved by EPA. By setting emission limits that would be protective of the most exposed nearby residents, these limits would also protect people with lower exposures; for example, people living farther away or people who occasionally pass through the area. The air emission limits were determined for the full-scale bioremediation effort by back-calculating from the adopted health risk criteria using risk assessment techniques. The following discussion presents the derivation of the short-term and long-term health protective emission limits which will be applied during the full-scale bioremediation of the French Limited site.

Short-Term Emission Limits Protecting Against Acute Health Effects

Because TLV-TWAs are not strictly based on acute effects, other literature sources describing acute adverse health effects were reviewed to determine other chemical concentrations at which acute effects might be manifested. Information reviewed included primary literature, supporting documentation for the TLVs, National Institute for Occupational Safety and Health (NIOSH) documents, and EPA documents. This review focused on identifying the lowest observed adverse effects levels (LOAELs) and no observed adverse effects levels (NOAELs) for acute effects.

The majority of the chemicals released during the bioremediation demonstration were hydrocarbons such as hexane, cyclohexane, heptane, or pentane. The concentrations of these hydrocarbons that might result in acute effects (within hours) start just below 100 ppm and range as high as thousands of parts per million, depending on the chemical. For the HSL compounds, however, concentrations ranging between tens and hundreds of parts per million could result in acute effects. The acute toxicology literature indicates that a total VOC concentration below 15 ppm would be expected to be protective against acute effects for the nearest residents, even when the total concentration monitored was assumed to be the most toxic HSL compound.

Long-Term Emission Limits Protecting Against Chronic Health Effects

Air criteria concentrations (ACCs) were established to protect against chronic adverse health effects. Because the ACC levels are much lower than the concentrations that could cause acute effects, by meeting the ACCs, it is also unlikely that acute health effects would occur.

The ACCs were derived for both carcinogenic and noncarcinogenic health effects by back-calculating from

acceptable exposure levels using risk assessment equations. The acceptable exposure levels were derived from acceptable health risk criteria approved by EPA. The acceptable health risk criteria were established as follows: the allowable potential increase in a person's excess lifetime cancer risk would be limited to 1 in 1 million per chemical, and the allowable potential noncarcinogenic risk would be limited to a hazard index of 1 per chemical. The ACCs required to achieve these health protection objectives were calculated for each of the HSL compounds as described below.

In order to derive the ACCs, the hazard index and excess lifetime cancer risk equations were rearranged to solve for the air concentration variable that will become the ACC. To accomplish this, all the variables in the equation, except for the air concentration, were assigned values.

Exposure assumptions were made for the nearest residents who are located in the Rogge, Dreamland, and Riverdale subdivisions. These potentially exposed residents were assumed to weigh 70 kg, breathe 20 m^3 of air per day, and have a 70-year lifetime. They were assumed to be at their residences, and therefore potentially exposed to lagoon emissions, every minute of every day for the entire 2 years of the full-scale bioremediation effort.

Bioavailability factors (BAFs) were incorporated into the derivation of the ACCs. These factors had not been previously used in the risk assessment on the bioremediation demonstration project because that assessment preceded EPA's published guidance on the use of BAFs (EPA, 1989). The BAF accounts for any potential differences between the absorption efficiency and biological effectiveness of the route and medium of inhalation exposure and the absorption efficiency and biological effectiveness of the route and medium of the experimental study from which the dose-response value (RfD or CSF) was derived.

When the RfD or CSF is based on exposure dose, the BAF is a relative adjustment factor defined as the ratio of the estimated absorption factor for the site-specific medium and route of exposure (air) to the known or estimated absorption factor for the laboratory study from which the RfD or CSF was derived. Use of this factor permits appropriate adjustment if the efficiency of absorption is known or expected to differ because of physiological effects and/or matrix or vehicle effects. When the RfD or CSF is based on absorbed or metabolized dose, the BAF is not a relative factor; rather it is an absolute factor expressing the expected bioavailability in humans. If the RfD and CSF are based on studies involving different exposure routes or matrices, then the BAF for evaluating noncarcinogenic effects may be different than the BAF for evaluating carcinogenic effects.

Compound-specific, effect-specific BAFs were determined for the HSL compounds based on reviews of available scientific literature. For chemicals with little information, availability of the dose to humans through inhalation exposure was assumed to be the same as that of the test species and the route and medium used in the experimental study.

As previously discussed, the health protection objectives of 1 in 1 million (1×10^{-6}) excess lifetime cancer risk for each potentially carcinogenic compound and a hazard index of 1.0 for each potentially noncarcinogenic compound were the established goals for the bioremediation of the French Limited site. Using these assigned values, the equations were solved and an ACC was derived for each of the HSL compounds. Table 5 presents the ACCs derived for the HSL compounds.

For potentially noncarcinogenic compounds:

$$ACC = 1.0 \div \left[\frac{Inhalation\ Rate \times BAF}{Body\ Weight \times RfD} \right]$$

For potentially carcinogenic compounds:

$$ACC = (1 \times 10^{-6}) \div \left[\frac{Inhalation\ Rate \times Lifetime\ Averaging\ Factor \times BAF \times CSF}{Body\ Weight} \right]$$

Because the BAFs, RfDs, and CSFs are chemical-specific, the ACCs will differ for each chemical. For chemicals potentially exhibiting both carcinogenic and noncarcinogenic effects, ACCs were derived for both health effects and the lowest ACC was selected for that chemical.

Managing Operations to Achieve Health Protective Emission Limits

Operating procedures during the bioremediation will be managed on the basis of air emission limits set as total VOC response action limits and chemical-specific ACCs. The total VOC limits are short-term emission limits designed to protect nearby residents from exposure to chemical concentrations that might result in short-term or acute adverse health effects. The ACCs are long-term emission limits designed to protect the public health from long-term or chronic carcinogenic or noncarcinogenic health effects.

To protect against potential acute health effects, continuous monitoring of total VOCs will be conducted at the top of the flood wall. Five monitoring stations will be positioned

TABLE 5

Air Criteria Concentrations (ACCs)

Compound	(ppb)	($\mu g/m^3$)
Acetone	220	530
Benzene	1.3	4.2
Bromodichloromethane	14.5	98.6
Bromoform	8.1	83.3
Bromomethane	1.5	6.0
2-Butanone	107	315
Carbon disulfide	3.2	10.2
Carbon tetrachloride	0.4	2.4
Chlorobenzene	3.7	17.5
Chloroform	6.1	30.4
Chloromethane	12.1	25.2
Dibromochloromethane	8.6	74.5
1,1-Dichloroethane	119	490
1,2-Dichloroethane	3.0	13.5
1,1-Dichloroethene	7.9	31.5
trans-1,2-Dichloroethene	17.6	70.0
1,2-Dichloropropane	0.4	1.8
cis-1,3-Dichloropropene	0.2	0.9
trans-1,3-Dichloropropene	0.2	0.9
Ethylbenzene	103	449
Methylene chloride	22.5	79.5
4-Methyl-2-pentanone	19.6	80.5
Styrene	245	1060
1,1,2,2-Tetrachloroethane	1.0	7.0
Tetrachloroethene	5.4	37.1
Toluene	521	2,000
1,1,1-Trichloroethane	190	1050
1,1,2-Trichloroethane	2.5	14.0
Trichloroethene	3.8	20.6
Vinyl Chloride	0.4	1.0
Xylenes	68.3	301

in the direction of the three nearest residential areas (Rogge, Dreamland and Riverdale subdivisions) and in the direction of two neighboring roads. The allowable short-term total VOC concentration of 5 ppm has been incorporated into the short-term response action limits. The total VOC concentration will be continuously monitored and bioremediation operations will be managed so as to avoid the attainment of acute VOC concentrations. In the unlikely event of an exceedance of the maximum short-term total VOC concentration (see discussion to follow), evacuation procedures will be conducted in order to prevent the occurrence of acute exposures to neighboring residents.

To protect against potential chronic health effects and to achieve the health protection objectives of 1 in 1 million (1×10^{-6}) excess lifetime cancer risk for carcinogenic effects and a hazard index of 1.0 for noncarcinogenic effects, long-term VOC concentrations will be monitored for each of the HSL compounds to ensure that they do not, on average, exceed the ACCs. A computerized system has been designed to continuously compare the chemical-specific ACCs with the cumulative average concentration modeled for that chemical at each of three residential locations (i.e., for the nearest resident in the Rogge, Dreamland, and Riverdale subdivisions). The ratio of the ACC to the cumulative average concentration is called the air criteria concentration ratio (ACCR). An ACCR will be derived for each chemical on a weekly basis throughout the 2-year period of the full-scale bioremediation project. The long-term VOC emissions during bioremediation will be managed such that the final ACCR will be equal to or less than 1.0 for each chemical, thereby protecting the public from adverse chronic exposures.

Measurement and Modeling Techniques

The remainder of this paper describes the sampling, analytical data management, and modeling techniques used to generate data for the risk assessment procedures described above. The program presented is the result of a cooperative effort between all participants in the project, the Task Group, ENSR, and EPA.

The Ambient Air Monitoring Program for potential releases of VOCs from the French Limited Bioremediation Process Operations includes two types of monitoring action: short-term monitoring and long-term, time-integrated monitoring.

Short-Term Monitoring. The short-term monitoring program provides a continuous, instantaneous reading of total VOC concentrations in ambient air. Five separate continuous measurements are taken at strategic locations around the operating bioremediation treatment cell, at the top of the French Limited lagoon flood wall, to determine whether control adjustments are necessary in

the bioremediation process to maintain total VOC concentrations within pre-approved limits established by EPA. Additionally, these measurements will be continuously recorded for historical purposes, and each measurement will trigger a process control alarm signal should it exceed a pre-set reading. The alarm point is selected to ensure that control action is taken before the pre-approved EPA limits are reached.

Long-Term Monitoring. The long-term monitoring program provides a 24-hour/day, 7 day/week continuous sampling of organic compounds in the ambient air at three French Limited site property line locations. These locations are directly between the bioremediation cell that is in operation and the three nearest potential receptors (the Riverdale, Rogge, and Dreamland subdivisions).

The air samples are analyzed daily to provide a time-integrated measurement of the 35 VOCs on the HSL. The concentrations determined in these measurements are then processed mathematically to identify the dispersion that will occur between the French Limited site property line and the three potential receptor locations. The potential receptor concentrations will be compared with the acceptable concentration criteria approved by EPA for the 2-year bioremediation operating period.

These daily long-term measurements will be continuously accumulated and averaged to derive a cumulative average for each compound on a weekly basis. The ongoing calculation of these ACCRs will be used to determine whether adjustments in the bioremediation operation are necessary in order to attain the project-specific health protection criteria. This chemical-specific average will be compared against the acceptable 2-year ambient air criteria approved by EPA.

Total Volatile Organics Short-Term Measurements

Results of short-term VOC measurement will be used to determine whether control action is needed to protect potential receptors from short-term exposures, to ascertain the effects of short-term concentrations on long-term health risk, and to ensure these effects are maintained within EPA-approved operational limits.

Organic vapor monitors (OVMs) will be permanently placed at five locations at the flood wall relative to the future operating bioremediation treatment cells. Figure 3 shows the placement of the analyzers for cell E and cell F. As can be seen from the figure, some monitoring locations will serve both cells but will represent a different relative position for each.

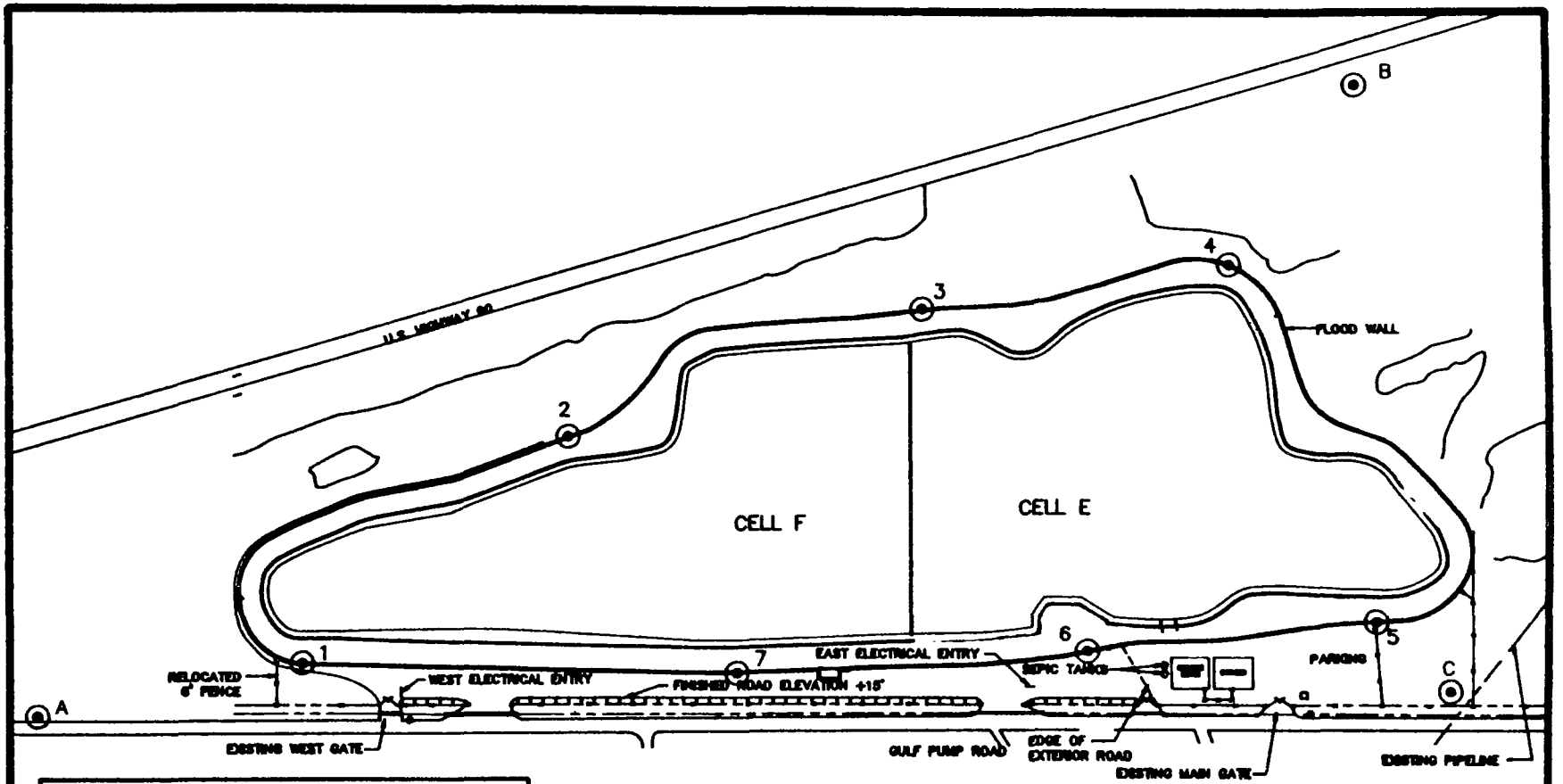

FIGURE 3

MONITORING LOCATIONS

	CELL F	CELL E
FLOOD WALL	1	1
	2	3
	3	4
	6	5
	7	6
FENCELINE	A	A
	B	B
	C	C

N

0 200 400

SCALE IN FEET

ENSR™

ENSR CONSULTING AND ENGINEERING

AMBIENT AIR MONITORING LOCATIONS

FRENCH LIMITED

DRAWN:	EDH	DATE:	8/22/90	PROJECT NUMBER:	REV.
APPV'D:	BD	REVISED:	X		0

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Measurements will be recorded as total VOCs, and calibrated as a relative response to benzene as iso-butene. A certified standard of approximately 8 ppm iso-butene will be used at all OVM stations.

VOC release response procedures have been developed and are presented in the French Limited Project RAP. VOC concentrations to be considered response action points are described later in this paper.

The short-term measurement system incorporates five Thermo Electron (TECO) 910A® OVMs at the flood wall, and an Odessa DSM 3260 Data Collector®, 386 computer, and custom-built alarm relay panel at the operations room. A functional block diagram of the approach is presented in Figure 4. This approach centralizes all monitoring data at one on-site location and provides the means for remote locations to connect to the system via telephone modem for transmitting current and historical data.

Each monitoring location will be equipped with one analyzer and zero and span gases. All analyzers will be connected to a central signal/data processing system in the operations computer room. The analyzers will be positioned, as shown in Figure 3, to represent monitoring the following general directions:

- Toward Rogge subdivision to the northeast.
- Toward Dreamland subdivision to the southeast.
- Toward Riverdale subdivision to the southwest.
- Downwind of the predominant wind direction to the northwest.
- Due south of the center of the then-active cell of the lagoon.

Specific locations will depend on which bioremediation cell is active, as specified in Figure 3. When bioremediation is complete in cell F, monitors 2 and 7 will be moved to locations 4 and 5, respectively. Shelters will be placed outside the flood wall and will be elevated against it to prevent possible damage caused by cranes and other vehicles inside the wall, or by flood events. The sample intake line will be a 1/4-inch Teflon tube with a sleeve of 1/2-inch conduit. Sampling points will be approximately 1 meter above and 1 meter inside the flood wall at each of the five locations. These are installed in accordance with the specifications of 40 CFR Part 58, Appendix E.

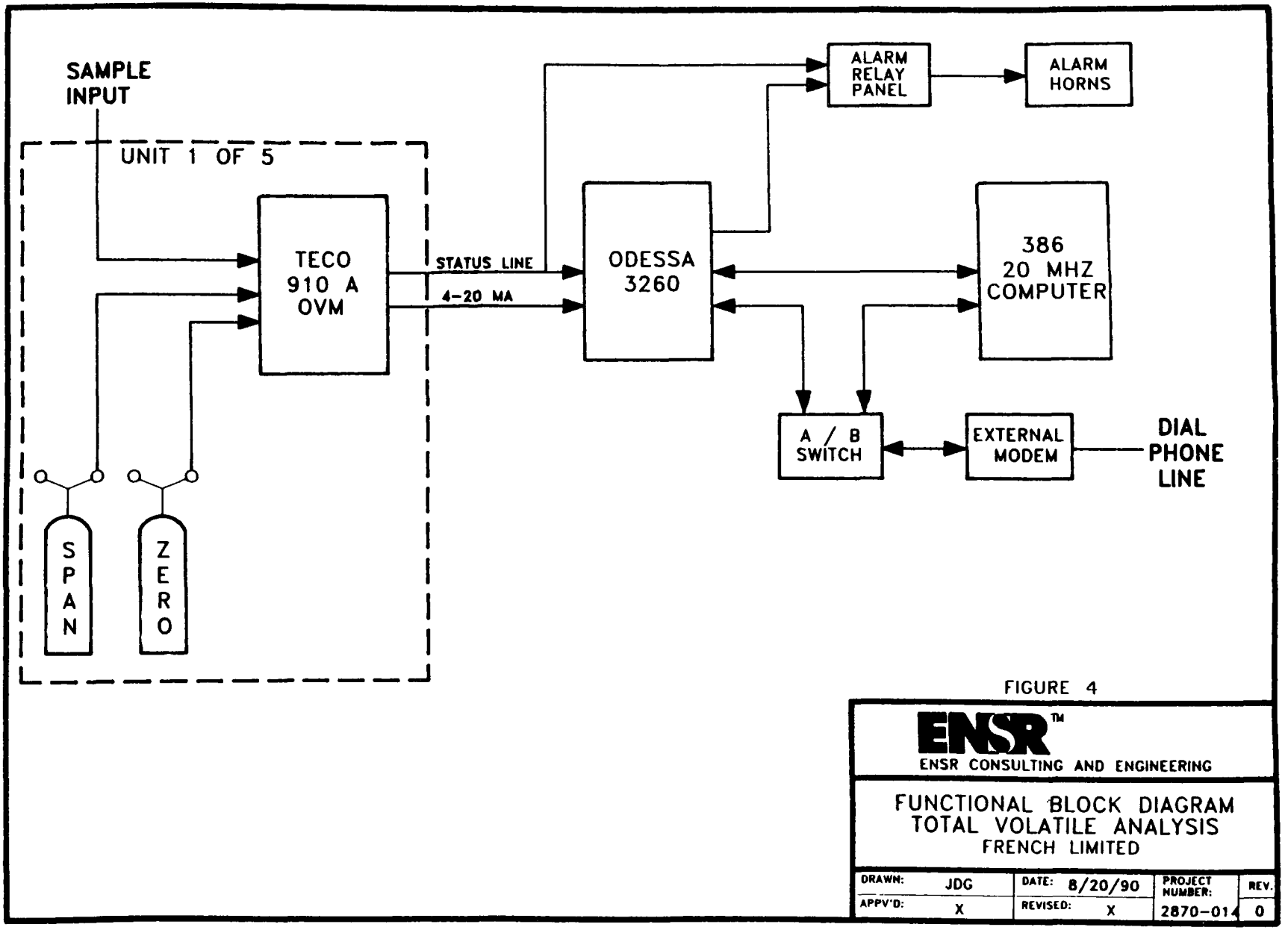
SAMPLE INPUT
UNIT 1 OF 5
TECO 910 A OVM
STATUS LINE
4-20 MA
ODESSA 3260
ALARM RELAY PANEL
ALARM HORNS
386 20 MHZ COMPUTER
A / B SWITCH
EXTERNAL MODEM
DIAL PHONE LINE
SPAN
ZERO
ENSR™
ENSR CONSULTING AND ENGINEERING
FUNCTIONAL BLOCK DIAGRAM
TOTAL VOLATILE ANALYSIS
FRENCH LIMITED
DRAWN: JDG
DATE: 8/20/90
PROJECT NUMBER: 2870-014
REV. 0
APPV'D: X
REVISED: X

FIGURE 4

TECO Analyzer

The TECO 910A® OVM, designed to be used on a continuous basis, uses a photoionization detector (PID) with a heated sampling flow path and a microprocessor to control calibrations and output. The detection limit of the method is 0.5 ppm as benzene.

Data Collector

The Odessa DSM 3260 Data Collector will convert the 4- to 20-mA signal from the remote analyzers into meaningful units in ppm. The DSM 3260 will be configured to provide interim averages of 5 minutes and final averages of 1 hour. The interim averages will be used for both alarm control and graphic presentation on the local computer screen. Each of the five OVMs will have a data collector channel recording its output and an associated alarm control set at 5 ppm. If the site experiences a 5-ppm-level alarm at one analyzer, it will also sound an alarm as more analyzers exceed 5 ppm; in addition, a calibration failure will trigger an alarm.

Software will be used to generate monthly summary reports of data collected. The reports will be included in the monthly project progress reports submitted to EPA. Data can also be accessed in real-time at the site or through a remote terminal via modem.

The OVM instrumentation and time-integrated sampling equipment will be installed, calibrated, operated, and audited, consistent with Standard Operating Procedures (SOPs).

The TECO 910® OVM is a self-calibrating instrument. A zero and span calibration check will be performed each hour. Each of these events will be 2.5 minutes in length. Zero and span calibration events will be staggered for the five sites so that only one analyzer at a time will be in calibration mode. The analyzer self-corrects to the span value.

As is normal with PID instruments, the analysis will be calibrated relative to a benzene standard. However, iso-butene is used as a surrogate standard to benzene to avoid potential exposure to benzene during calibrations. The instrument is calibrated to iso-butene's corrected response relative to benzene (iso-butene is generally provided by the supplier as a benzene equivalent concentration). The analyzer, therefore, will be calibrated in parts-per-million as benzene even though an iso-butene standard will actually be used. An approximately 8 ppm certified standard of benzene equivalent to iso-butene will be used at each OVM station.

At installation and quarterly thereafter, a multi-point calibration will be conducted to verify the daily calibrations. This audit calibration check will be conducted with calibration gases different from those used for the daily calibration.

Audit of calibration data control charts, field repair forms, and other associated recordkeeping will also be conducted quarterly in conjunction with the multipoint calibration performance audit.

Results of the total volatile organics short-term measurements will be reported in three ways:

- Results will be tracked in real-time on the monitor screen at the site computer system. These results as they are updated can also be accrued from remote computer terminals via modem.
- A field log will be kept at the site which will include a summary of dates, results to-date which have been quality assurance checked, and notations of any events where action events have been exceeded.
- Quality assured data summaries will also be included in the monthly project progress reports submitted to EPA.

Any time total VOC concentrations exceed predetermined action limits at a monitoring location at the top of the floodwall, response actions will be implemented in accordance with the following plan.

Site Operational Condition	Total VOC Concentration	Duration	Response Action
Green	0-5 ppm	Indefinite	Normal operation
Yellow	5-11 ppm	More than 5 minutes	Reduce aeration and mixing intensity.
Red	5-11 ppm	More than 30 minutes	Shut down aeration and mixing; conduct specific target volatile sampling at top of flood wall.
White	>11 ppm	More than 30 minutes	Evacuate on-site personnel.

The site alarms sound upon reaching the yellow site operational condition.

All concentrations specified are pending confirmation from long-term risk assessment results. Levels will be adjusted, if necessary, to aid in the maintenance of long-term average levels. This monitoring is intended to identify the types of compounds present during these elevated concentration periods.

If white concentrations persist after mixing and aeration operations have been shut down, meteorological conditions will be analyzed and the downwind property line total VOC concentration determined by use of portable OVM instrumentation similar in response to the fixed flood wall monitors. The portable OVM will be used routinely for on-site health and safety monitoring. If this concentration is less than 2.0 units, the downwind property line monitoring will continue until on-site readings return to normal. If this reading exceeds 2.0 units and continues at that level for more than 15 minutes, an evacuation notice will be issued. If closure of a public road is warranted, the road will be blockaded with traffic flares until the Sheriff's Department arrives on the scene. The French Limited Task Group Project Coordinator, EPA Project Manager, TWC Project Manager, Texas Air Control Board, and Harris County Pollution Control Department will be notified of the situation.

Emergency controls will remain in effect until it has been determined, to the satisfaction of the Sheriff's Department, that conditions have returned to normal and blockades or evacuations can be withdrawn.

As soon as emergency controls are removed, the Task Group will establish communications with nearby residents and community leaders to describe the situation that occurred, the actions taken to control it, and the actions being taken to prevent reoccurrence. Any contact with the public will be made in person. The public will not be expected to hear or respond to site alarms which trigger during the yellow operational condition.

This emergency plan will be reviewed with the Harris County Emergency Coordinator prior to startup of the bioremediation program.

After emergency controls have been removed, site personnel will establish communications with the Task Group Project Coordinator. The situation that occurred will be described (with the ambient air total VOC concentrations), and plans to prevent reoccurrence established. The Task Group Project Coordinator will review the situation with the EPA Project Coordinator within 24 hours of the occurrence. They will follow the procedures outlined in the approved Contingency Plan. Upon EPA and Task Group concurrence, bioremediation operations will be resumed. The re-startup will follow the normal process (with any modification resulting from the incident) of startup of aeration

followed by startup of mixing activity, with continuous monitoring of ambient air total VOC concentrations throughout the sequence.

Within 60 days of the incident, the Task Group Project Coordinator will submit a detailed report to EPA giving:

- Date/time of incident.
- Description of incident.
- The complete total VOC concentration database during the incident.
- The complete meteorological database during the incident.
- Description of notifications given.
- Description of agency and public communications initiated.
- Re-startup date/time and special procedures followed.
- Description of actions taken to prevent reoccurrence.

The report to EPA will serve as an historical record of the incident. It will be a document of reference for further discussion, if any, concerning the events that took place during and immediately following the incident.

Time-Integrated VOC Measurements

Routine time-integrated VOC measurements will be taken at the property line to provide data for determining possible long-term health risk from air emissions from the site. Ambient air will be sampled by Tenax® and carbon molecular sieve (CMS) absorbent tubes and analyzed for the 35 HSL target VOCs by GC/MS.

A 2-year health risk will be calculated weekly using the total project analytical database available each week. Each week's results will be added to the project-to-date database prior to the week's health risk calculations. Operations will be controlled to ensure that, by the end of the remedial action project, the long-term health risk at each of the three nearest receptor locations (Riverdale, Rogge, and Dreamland) has been maintained within EPA-approved health risk criteria. Results of health risk calculations will be recorded in the log at the site, where they will be available for inspection and use by operations personnel and review by regulatory agencies. Results will also be included in the monthly project progress reports to be submitted to EPA.

Time-integrated sampling will be conducted at three fenceline locations on a line between the subdivisions of interest and the operational cell of the lagoon. Approximate locations of the sampling, corresponding to the Rogge, Dreamland, and Riverdale subdivisions, are shown in Figure 3. Final locations will depend on physical limitations of the site. Efforts will be made to locate the sites on as direct a line as possible. The same type of shelter will be used as for the total organics measurement equipment.

Throughout the remediation period, 24-hour integrated samples will be collected daily, 7 days per week. Sampling will only be suspended due to severe weather conditions at the site. Time-integrated measurement samples will be collected on Tenax® solid sorbent cartridges and collocated CMS cartridges, and analyzed by thermal desorption GC/MS. Air samples will be collected by drawing the sampled air through the cartridges of precleaned Tenax® and CMS sorbent at a measured flow rate, using an electrically operated sampling pump. A second cartridge will be placed downstream of the first cartridge to facilitate detection of any breakthrough. One pump will be used for each cartridge set.

The sampling flow rate will be controlled using a Mass Flow Controller. Each cartridge set (Tenax® and CMS) will be controlled by an individual mass flow controller. Nominal sampling volumes of 20 liters for Tenax® and 30 liters for CMS will be used. Mass flow controller accuracy will be checked at least quarterly, according to EPA protocols. Battery-operated Alpha personnel sampling pumps will serve as backup in case of an individual station power failure. Samples will be properly packaged and forwarded to the off-site laboratory for GC/MS analysis. Samples will be thermally desorbed in a heated chamber onto a GC column for GC/MS analysis. GC/MS analysis will be used to determine the presence and levels of the 35 VOCs.

Of the 35 HSL target compounds, five compounds will be determined using CMS and the remaining 30 using Tenax®. Table 6 presents the five compounds to be determined by CMS, with the expected detection limits for each. The detection limit assume a nominal 30-liter sampling volume and a 25-ng GC/MS detection limit per compound. Table 7 presents the same information for the Tenax®-sampled compounds. These limits for Tenax®-sampled compounds assume a nominal 20-liter sampling volume.

The sampling program will include the preparation of one field blank for each day of sampling. One duplicate run will be made per week of sampling.

Laboratory results reports will be compiled by the French Limited Task Group Data Manager. Laboratory determinations will be combined with field log data on sample flow and sampling time

TABLE 6

Compounds Determined by CMS

Compound	Method Detection Limit*
Chloromethane	0.4 ppb
Bromomethane	0.2 ppb
Vinyl chloride	0.3 ppb
Chloroethane	0.3 ppb
Methylene chloride	0.2 ppb

*Based on 30-L sampling volume and 25-ng/compound GC/MS detection limit

TABLE 7
Compounds Determined by Tenax

Compound	Method Detection Limit*	Compound	Method Detection Limit*
Acetone	0.5 ppb	Dibromochloromethane	0.1 ppb
Carbon disulfide	0.4 ppb	1,1,2-Trichloroethane	0.2 ppb
1,1-Dichloroethene	0.3 ppb	Benzene	0.4 ppb
1,1-Dichloroethane	0.3 ppb	trans-1,3-Dichloropropene	0.3 ppb
trans-1,2-Dichloroethene	0.3 ppb	2-Chloroethyl-vinylether	0.3 ppb
Chloroform	0.2 ppb	Bromoform	0.1 ppb
1,2-Dichloroethane	0.3 ppb	4-Methyl-2-pentanone	0.3 ppb
2-Butanone	0.4 ppb	2-Hexanone	0.3 ppb
1,1,1-Trichloroethane	0.2 ppb	Tetrachloroethene	0.2 ppb
Carbon tetrachloride	0.2 ppb	1,1,2,2-Tetrachloroethane	0.2 ppb
Vinyl acetate	0.3 ppb	Toluene	0.3 ppb
Bromodichloro-methane	0.2 ppb	Chlorobenzene	0.2 ppb
1,2-Dichloropropane	0.2 ppb	Ethylbenzene	0.3 ppb
cis-1,3-Dichloropropene	0.3 ppb	Styrene	0.3 ppb
Trichloroethene	0.2 ppb	Total Xylenes	0.3 ppb

*Based on 20-L sampling volume and 25-ng/compound GC/MS detection limit.

to calculate the 24-hour average concentration of each of the target compounds. These data will be compiled in Lotus spreadsheet form suitable for input to fenceline impact calculations.

Time-integrated sampling will be conducted at the initiation of remedial activities in each of the operational cells of the lagoon, as well as at the three fenceline locations. This sampling will be conducted at a downwind floodwall short-term monitoring location for five consecutive days during the first week of operation of the first cell. Flood wall sampling will be repeated during the first week of the second cell operation and at significant changes in aeration or mixing activities. The downwind location will be selected on the basis of the predicted 24-hour wind direction. Samples will be taken over a 24-hour period with all sampling and analysis procedures the same as for the fenceline locations. Samples most likely to have the highest concentrations from 2 of the 5 days of sampling will be selected to be analyzed. These samples will be quantitatively analyzed for the same compounds as those collected at the fenceline locations. In addition, the analytical results data will be qualitatively reviewed to identify major compounds present. The purpose of these qualitative determinations is to identify compounds that might be present which were not included in the target list quantitative determinations, and to investigate whether qualitative compositional changes have occurred in the air emissions.

Sampling for specific target volatiles will also be conducted at the onset of a red site operational condition. The purpose of this sampling is to qualitatively identify the compounds which constitute the total VOC concentrations measured. Samples will be taken at the flood wall at the short-term monitor that triggered the red condition. If more than one monitor is at the red range, samples will be taken from the site of the monitor reporting the highest value. As soon as possible after the red site operational condition has been reached, a sample will be collected. An air volume of at least 10 liters will be collected for both the Tenax® and CMS sampling techniques. A sampling time of 30 minutes will be used to minimize the averaging period. If the site operational condition decreases to a yellow or green level during sampling, sampling will be completed, but a notation made of the time when the level dropped below the red level. At least one 30-minute sample will be analyzed for each day that operational response condition sampling is conducted. Samples which are most likely to have the highest concentration will be selected for analysis. Samples taken will be immediately sent to the laboratory and given priority for analysis. Analysis procedures will be the same as other time-integrated measurements. Results of the analysis will be reported immediately upon completion to the French Limited Task Group Project Coordinator.

The results will also be included in documentation describing the total VOC short-term measurement results for this time period.

Modeling Air Impacts

The overall purpose of the Ambient Air Monitoring and Control Program (AAMCP) modeling phase is to ensure that the ambient impacts due to the bioremediation of the French Limited site at the three closest residential subdivisions are within acceptable limits. This will be accomplished by estimating average weekly and project-to-date ambient impacts at these residential subdivisions and comparing these impacts with health-protective criteria.

Ambient impacts due to the bioremediation of the French Limited site will be estimated on a weekly basis for each of the 35 compounds measured at the fenceline sampling locations in the time-integrated sampling phase. The time-integrated sampling data gathered at the fenceline sampling locations, together with an EPA guideline dispersion model and on-site meteorological data, will be used to calculate the ambient impacts from the French Limited remediation operations at the closest three residential subdivisions.

The system, in large part, will be computerized, with only minimal manual requirements. The structure of the modeling system can be divided into three major sections:

1. Calculation of average weekly and project-to-date French Limited impacts at the fenceline sampling locations.

2. Calculation of dilution factors to estimate the average weekly and project-to-date French Limited impacts at the residential subdivisions.

3. Calculation of ACCRs.

A flow chart of this process is shown in Figure 5. Each of these steps is discussed in detail below.

The time-integrated fenceline sampling program discussed previously will measure the ambient concentrations of 35 compounds. The data will be collected over a 24-hour time period and will therefore represent 24-hour average concentrations. These data, in conjunction with the individual compound detection limits and ambient background concentrations, will be used to calculate the weekly and project-to-date fenceline impacts due to the bioremediation of the French Limited site.

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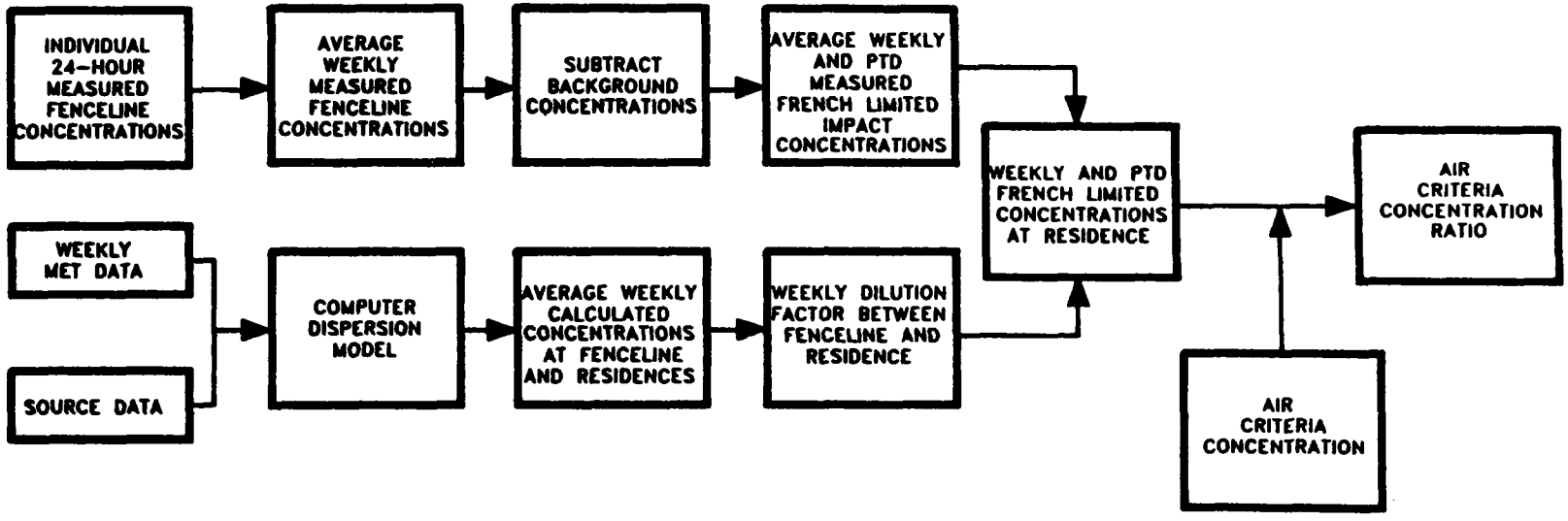

PTD - PROJECT TO DATE

FIGURE 5

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FLOWCHART FOR AIR MODELING

FRENCH LIMITED

DRAWN:	JDG	DATE: 12/18/90	PROJECT NUMBER:	REV.
APPV'D:	X	REVISED: X	2870-014	0

The compound detection limits come directly from the fenceline measurements program. It was previously determined that ambient background concentrations of benzene, toluene, and xylene occur due to Houston regional area sources (vehicles, industrial, commercial uses, etc.). These background levels are estimated to be 1.7, 1.6, and 1.5 ppm for benzene, toluene, and xylene, respectively.

The weekly and project-to-date French Limited fenceline impacts will be calculated by first averaging the individual, measured 24-hour compound concentrations to develop total impact concentrations (i.e., French Limited plus background). Individual measured concentrations, which were determined to be below detection limits, will be set to one-half their respective limits. The final step in developing French Limited fenceline impacts is to subtract the background concentrations from these values.

The individual 24-hour compound concentrations will be manually loaded into a computerized database on a weekly basis. That is, each week a full set of compound concentrations for each of the three fenceline locations will be entered into the database. A program will then be executed each week to determine average weekly and project-to-date ambient concentrations and French Limited impacts at the fenceline locations. Figure 6 is a flow chart of this process.

These calculations will be performed with a computerized dispersion model developed for EPA. In many applications, compound emission rates would be directly placed into an atmospheric dispersion model, and the model would then calculate the impact of those emissions at specific receptor locations. Because reliable compound emission rates are not available for the remediation process, however, another method must be used.

A dispersion model will be used to calculate impacts at the fenceline sampling and residential receptor locations using a generic (i.e., normalized) emission rate. A dilution factor (DF) will be calculated for each receptor pair. This dilution factor will then be applied to the French Limited fenceline impacts to determine the receptor-residence ambient impacts.

The dispersion model will be used as the computational core for this process, and other computerized software will be placed around it to automate the procedure. Dispersion model calculations will be performed on a weekly basis using weekly meteorological STAR frequency distributions. Project-to-date impacts will be calculated from the weekly results. Figures 7 and 8 are flow charts of this process.

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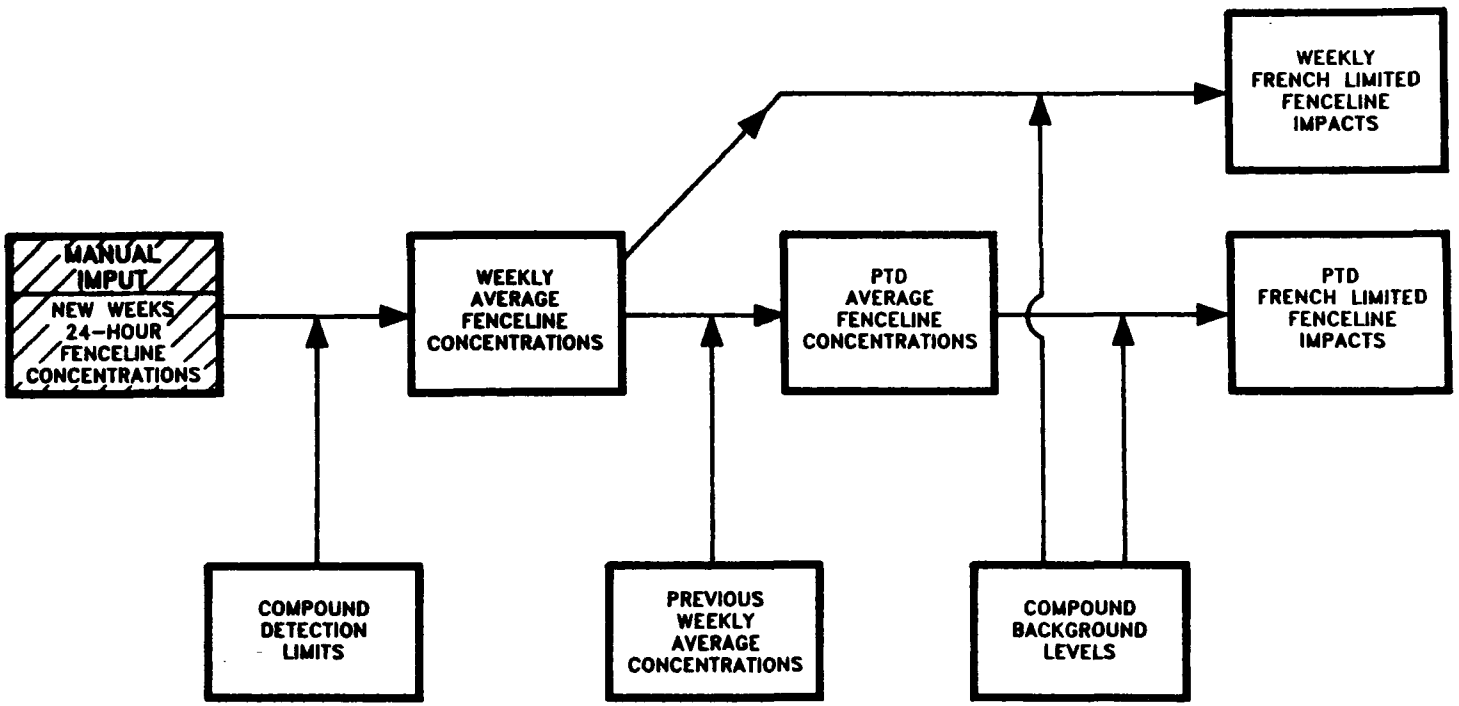

FIGURE 6

ENSR™

ENSR CONSULTING AND ENGINEERING

DATA FLOWCHART FOR CALCULATION OF FRENCH LIMITED FENCELINE IMPACTS

FRENCH LIMITED

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APPV'D:	X	REVISED: X	2870-014	0

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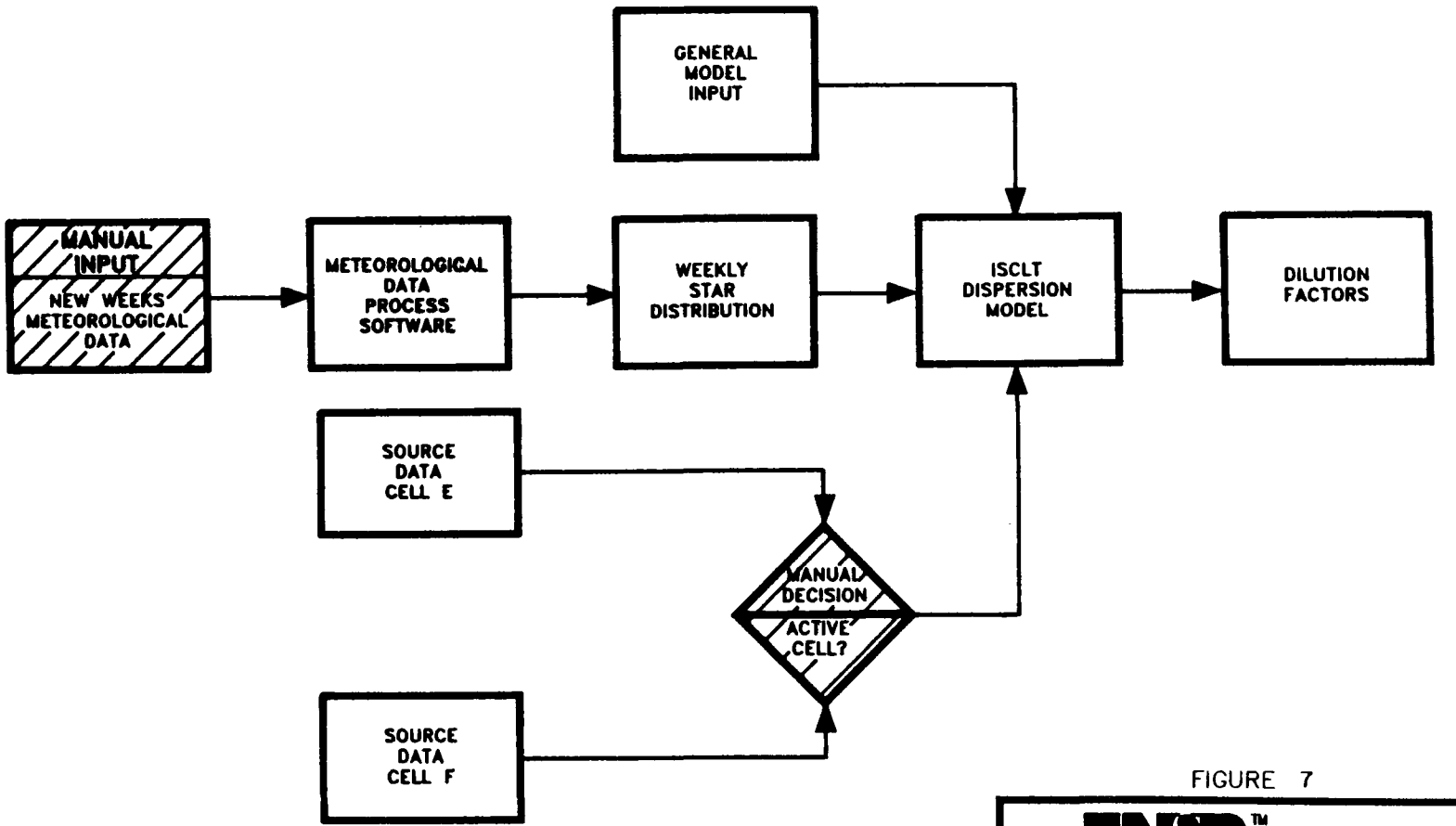

FIGURE 7

ENSR™

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DATA FLOWCHART FOR CALCULATION OF DILUTION FACTORS

FRENCH LIMITED

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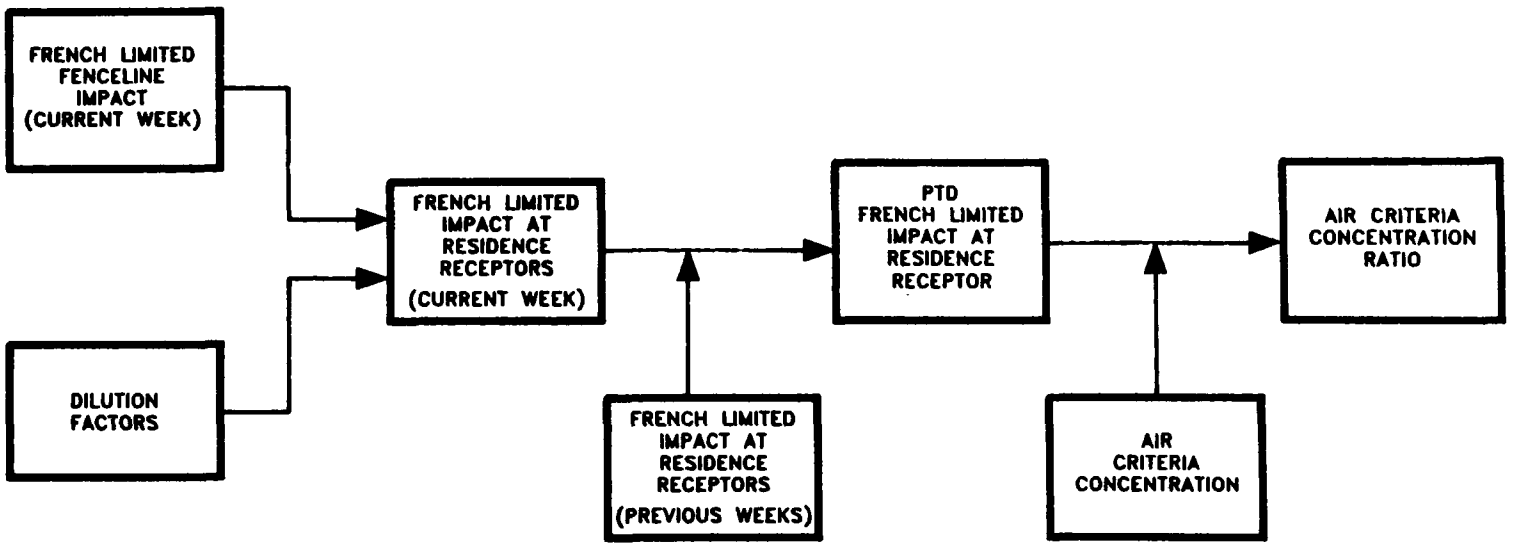

FIGURE 8

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DATA FLOWCHART FOR CALCULATION OF ACCRs

FRENCH LIMITED

DRAWN: JDG	DATE: 12/18/90	PROJECT NUMBER:	REV.
A-PV'D:	REVISED:	2870-014	0

In addition to the atmospheric dispersion model, the specific data necessary for these calculations are: meteorological data, source parameters (location, emission rates, and release parameters), and location of receptors (i.e., points for which concentrations are to be calculated). Each of these is discussed in detail below.

A meteorological station will be operated continuously during the remediation activity. The station will consist of:

- A free-standing 10-meter tower.
- A wind speed and direction sensor at the 10-meter level on the tower.
- A temperature and relative humidity sensor (with radiation shield) at the 2-meter level on the tower.
- A barometric pressure sensor located inside a shelter adjacent to the tower.
- A tipping-bucket rain gauge (with wind screen) located at ground level near the tower.
- A data acquisition hardware and software system to record digital data from analog signals produced by the meteorological sensors. This data acquisition system will be located in the field laboratory near the tower.

In addition to recording average values for each of the parameters monitored (totals for rainfall), the data acquisition system will calculate and record averages of standard deviation of wind direction, commonly called sigma theta. The sigma theta variable is a measure of atmospheric turbulence, a parameter important in determining atmospheric dispersion characteristics.

The data acquisition system will calculate 5-minute and hourly averages. Hourly averages will be recorded and used for impact calculations for the time-integrated concentration measurements.

The hourly averages will be summarized into the various reports as follows.

- Hourly data recovery (monthly)
- Mean wind speed (monthly)
- Vector wind direction (monthly)
- Temperature (monthly)
- Barometric pressure (monthly)
- Precipitation (monthly)
- Percent frequency-wind rose (monthly)
- Hourly observations (daily)

The equipment specified to be used meets or exceeds EPA-recommended specifications (EPA, 1987).

The quality control procedures for the meteorological measurements are designed to maintain equipment accuracy and acceptability within the tolerance limits given in Table 8. Criteria for the validation of collected data are shown in Table 9.

Weekly and project-to-date STAR frequency distribution will be developed each week after the new week's meteorological data have been manually verified according to established data validation procedures. The data will then be inserted into the permanent hourly database. The STAR data represent frequency distribution of wind speed, wind direction, and atmospheric stability. This weekly STAR frequency is the meteorological data that will be used in the dispersion model analysis.

EPA's Industrial Source Complex (ISC) dispersion model will be used to simulate ambient impacts from the lagoon at the three fenceline sampling location receptors and three residential receptors. The ISC model is an EPA guideline model capable of simulating dispersion from point, volume, and area sources in both urban and rural dispersion environments. The long-term version of ISC (ISCLT) will be used to calculate normalized project impacts at the fenceline and residence receptor locations. ISCLT uses a meteorological joint frequency distribution of wind speed, wind direction, and atmospheric stability class (STAR distribution) to estimate long-term average ambient impacts.

The basic concept of the dispersion modeling will be to calculate the average weekly impacts at both the fenceline and residential receptors using a generic emission rate. By dividing the normalized residence-receptor impact by the fenceline-receptor impact, a normalized dilution factor for the fenceline/residence receptor pair is obtained. This dilution factor can then be applied to the weekly average French Limited impact at the fenceline to estimate the weekly average French Limited impact at the residence receptor location. Average project-to-date French Limited impacts will then be calculated by averaging the weekly impacts.

Model calculations will be performed at six receptor locations: the three fenceline sampling locations and the three closest residential subdivisions. The three subdivisions, Rogge, Dreamland, and Riverdale, are located to the northeast, south-southeast, and south-southwest of the French Limited site, respectively.

TABLE 8

Recommended Meteorological Tolerance Limits for Audit Results

Parameter	Limits[1]
Wind Speed	±1.12 mph
Wind Direction	±5°
Temperature	±0.5°C
Relative Humidity	±1.5% RH
Precipitation	±10%

[1]Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV, Meteorological Measurements EPA 600/1-82-060, February 1983.

TABLE 9

Summary of Meteorological Data Performance Goals

Parameter	Units	Validation Limit (% of true)	Data Recovery Rate (% of possible)
Wind speed	mph	±5 mph	90%
Wind direction	Degrees compass	±20°	90%
Temperature	Degrees celsius	±3°C	90%
Barometric pressure	Inches of mercury	±2 in. of mercury	90%
Precipitation	Inches	±0.01 inch	90%
Relative humidity	%	±5%	90%

The average compound concentrations produced by the French Limited operations that are acceptable at any residence, assuming a full 2 years of remediation, have been calculated. These acceptable average compound concentrations are referred to as the Air Criteria Concentrations (ACC) and are shown on Table 5 in both ppb and $\mu g/m^3$. The ratio of the ACC to the calculated French Limited impact at receptor-residences is referred to as the ACC Ratio (ACCR). This ratio should be below 1.0 for each compound at the end of the 2-year remediation program.

As an operational tool to ensure that the final ACCRs will not exceed 1.0, they will be tracked on a weekly basis. If one or more of the compound-specific ACCRs is above 1.0 during the program, necessary operational changes can be made to reduce the emissions and atmospheric impact of the process.

The overall purpose of the modeling phase is to produce a simple measure of the remediation operation's impact on acceptable ambient air concentrations levels at the nearest residences. This will be accomplished with the calculation of ACCRs for the 35 HSL compounds measured by the fenceline air sampling program.

The final product of the modeling phase will be three tabular reports, one for each sampling location/residence pair, which will be produced weekly, listing the following information for each chemical:

- Current weekly average French Limited impact at monitor sampling location.
- Project-to-date average French Limited impact at monitor sampling location.
- Current weekly average French Limited impact at residence receptor location.
- Project-to-date average French Limited impact at residence receptor location.
- Number of valid samples incorporated into weekly and project-to-date average.
- Weekly ACCRs.
- Project-to-date ACCRs.

A copy of these reports will be kept on-site for review by operations personnel for their use in decisions on future operations at the site and for review by regulatory agencies. The report will also be included in the monthly project progress reports.

CONCLUSIONS

The evolution of the Ambient Air Management Program for the French Limited site was the result of a conscious effort throughout the project to consider air impacts. The database developed thus far is one of, if not the most, comprehensive for a Superfund site. Evaluation of the data and the risk-based monitoring programs developed establish a high level of confidence that the final remedial effort will accomplish its ambient air quality management goals. The program developed for this site can serve as a model for similar remediation efforts where there is concern over air impacts. Possibly more importantly, this program has shown that ambient air quality management should not be thought of as a hinderance to remedial activities, but as an integral part of the overall process.

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Remedial Construction at the Industrial Waste Control Site, Fort Smith, Arkansas

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INTRODUCTION

The Industrial Waste Control (IWC) site is a closed and covered industrial landfill built in an abandoned surface coal mine. The site was closed in 1978 by the Arkansas Department of Pollution Control and Ecology (ADPC&E) after contaminants migrated off-site. In 1982, the IWC site was added to the National Priorities List of hazardous waste sites. In June 1988 a remedy was selected for the site and in October 1989 remedial construction began. Construction was completed in December 1990, ahead of schedule and for a cost less than that originally estimated.

The purpose of this paper is twofold: First, to describe the most significant portion of the remedial construction activities that were performed by the Potentially Responsible Party Steering Committee (referred to as the IWC Steering Committee) with oversight by the U.S. Environmental Protection Agency (EPA). These activities included excavation of buried drums, stabilization/solidification of contaminated soils, and construction of a slurry wall and French drain system. Second, to present the lessons that were learned in completing this many-faceted remediation project.

Because very few remediation projects have actually been completed nationwide, it is important that those projects that have been completed, serve as learning tools for future projects. In this paper, the lessons learned at the IWC site are presented for consideration in conducting future remediation projects.

SITE BACKGROUND

The IWC site covers 8 acres and is located about 7 miles southeast of Fort Smith, Arkansas. The site was built on an abandoned surface coal mine. Coal mining occurred in the area from the 1800s to the 1940s. Around the site, several undergrond mines operated until 1935. Surface strip mining took place onsite during the 1940s. Disposal of construction debris and industrial wastes began sometime in the late 1960s. In 1974, the IWC owner/operator obtained a state permit for an industrial landfill. Until mid-1978 a wide variety of liquid and solid wastes, including painting wastes, solvents, industrial process wastes, and metals were disposed at the site.

During its operation as a landfill, the site consisted of a number of large trash and industrial waste disposal areas and 2 liquid waste surface impoundments. In the spring of 1977 a heavy rain caused one or more of the impoundments to overflow. This overflow contaminated surrounding livestock pastures and a pond on a nearby farm. As a result, the ADPC&E closed the site in 1978 by covering it with soil. After the closing, ADPC&E and EPA conducted field surveys and found contaminated soils and leachate on the site. EPA conducted preliminary assessments in 1980 and in 1981. In 1982, EPA placed the IWC site on the National Priorities List (NPL) of hazardous waste sites. EPA

conducted a phased Remedial Investigation (RI) during the summers of 1984 and 1985 and a Feasibility Study (FS) in early 1986.

In mid-1986, the IWC Steering Committee requested permission to conduct additional studies to further define the locations of buried drums and the extent of contamination. The study, which included trenching and visual inspection for the locations of buried drums, and soil sampling and analyses, to quantify the extent of contamination, was approved by EPA and was conducted by the Steering Committee in 1986-87.

Results of the EPA and IWC Steering Committee investigations indicated that there were five areas of concern at the site (See Figures 1, 2 and 3):

- Area A is an old surface mine used as a landfill. It contained wood products and some solid industrial wastes.
- Area B received secondary contamination from subsurface leaks from area D and overspills from area C.
- Area C contained abandoned surface ponds used during landfill operations for evaporation of organic-rich liquids, solvents, paint thinners, etc. This area contained significant volumes of contaminated soils and waste sludges.
- Area D contained buried drums filled with organic liquids and contaminated solids. This area was a major source of contamination for areas A and B.
- Area 09B (See Figure 3) was where ground water samples showed contamination in the perched zone.

Based upon the results of both the initial RI by EPA and the supplemental investigation by the Steering Committee, the following conclusions were reached:

- The primary contaminants of concern are methylene chloride, ethylbenzene, toluene, xylene, trichloroethane, chromium, and lead.
- Up to 3000 liquid filled buried drums may exist in Area D.
- Up to 5800 solid filled buried drums may exist in Areas A and C.
- Contaminated soils exist in Areas A and C and possibly near well 09B.
- Very little ground water contamination has occurred. The most contaminated ground water is in a perched zone, near well 09B. This zone has a very low yield.

In 1988, EPA selected the following site remedy (See Figure 3):

- Buried drums are to be excavated from Area D. Liquids from the drums are to be disposed off-site at an approved RCRA facility.
- Contaminated soils from Areas C and D and around ground water monitoring well 09B are to be excavated, stabilized onsite, and returned to Area C. The stabilized matrix must pass the Toxicity Characteristic Leaching Procedure (TCLP) test, as well as the ASTM strength test.

- A slurry wall is to be installed around the stabilized soils.
- A French drain system is to be installed along the south, west, and east sides of the site to intercept and divert shallow ground water around the site. An impermeable barrier, such as a slurry wall, is to be installed on the site side of the French drain to prevent onsite ground water from entering the French drain.
- A multilayer RCRA cap is to be constructed to cover the area bounded by the French drain system and the northern site boundary.
- Monitor onsite and adjacent ground water and impose land use restrictions.

DISCUSSION

After US EPA approved the remediation design documents, construction started on October 16, 1989. The following discussion describes the excavation of buried drums, the construction of the slurry wall and French drain, the stabilization of onsite soils, and the capping operations. The lessons learned during these remedial activities are also described.

Drum Excavation

In accordance with the approved plans, the upgradient and downgradient sides of the Area D excavation were bordered by clay berms to prevent run-on and run-off during excavation. An area 100 feet by 75 feet with a depth ranging from 6 to 12 feet eventually was excavated. It was planned that soil and drum excavation be accomplished primarily using backhoe equipment with a drum grappler to lift drums out of the excavation, even though some manual excavation may be required. Potentially contaminated soils were also removed during the drum excavation process. This soil was staged for later screening to determine which soil required stabilization. (This paper does not describe the screening process.)

A 1:5 entrance ramp was first excavated down into the east side of Area D. A single drum was found during the ramp excavation. After removing 1.5 feet of soil from the entire area, excavation proceeded, using a backhoe, moving out from the ramp from east to west. Drum excavation proved very difficult since the drums were corroded and in various states of disintegration. When a liquid-containing drum was unearthed and it was leaking or it was too deteriorated to withstand the stress of removal, it was tapped and its contents were pumped to a new drum (See photo 2 showing a drum in backhoe bucket being pumped empty). Excavated drums were removed from the area and staged in a drum staging area for final disposal. Even though great care was used in trying to minimize the tearing of drums or spilling of drum contents during excavation, spillage did occur. When spillage occurred, the spilled drum liquids were mixed with clean soil and Class C Flyash (CFA) and moved to the Soil Staging Facility (SSF), where it was stored for solidification later, with other contaminated soils.

On January 23, 1990, during excavation on the south wall of Area D, several full drums were discovered. One drum was 4 ft below grade and partially embedded in soil. The drum was leaking an orange material. Water was continually seeping from the face of the excavation near the drum. The contractor attempted to control water around the drum by pumping and adding flyash. Simultaneously, the contents of the deteriorating drum were pumped to a new drum. A cap was put on the new drum after it was filled to the desired level. As the drum was being hoisted out of the excavation, it was noticed that the drum was becoming warm. As the drum was placed on the ground outside of the excavtion area, workers noticed that the drum was expanding. The contractor tried to remove the bung cap, but only succeeded in loosening it before the pressure caused foam to spew

from the drum. The contractor immediately evacuated personnel from the drum area and closed the perimeter road. The drum was observed from upwind, across the excavation area, using binoculars. After approximately 15 minutes, the drum swelling caused the drum to tilt 20 degrees from the vertical (photo 3) and the bottom seam opened up about 6 inches. Soon afterwards, the seam burst and the drum was propelled into the air. The drum rose approximately 200 feet up in the air (photo 4) and landed 260 ft away from it's original location. The contractor arrived at the impact point and measured 3 parts per million total volatile organics with an Hnu meter. Scattered pieces of foam were found at the impact area. The foam was collected, and soil in a 4 foot by 4 foot area, and 2 inches deep, around the impact point was removed and brought back to the site. A sample was taken from this soil for analysis. The analysis showed no site-related contaminants above background levels.

EPA then ordered all drum excavation activities halted until the incident was thoroughly investigated and corrective measures were taken to avoid additional incidents. EPA, the EPA oversight contractor, the IWC Steering Committee construction contractor, and personnel from the PRP companies, participated in the investigation.

During the investigation, personnel from one of the PRP companies identified the foam found around the drum impact point as a resin that was used by their company to manufacture refrigerators. It is known that the foam is formed when this resin is combined with water. Based upon this finding, it was concluded that water seeping from the side of the excavation entered the partially buried drum, which contained the resin used in the manufacturing process. The water and resin were then pumped to the new drum, where the water caused the resin to polymerize and become foam. The pressure created within the drum when the resin, transformed into foam, caused the drum explosion.

On February 20, 1990, EPA issued its approval for the PRP contractor to resume drum excavation, with a number of modifications to the drum excavation procedures. Some of the more important modifications were:

- Drums are to be located using techniques which will not disturb, puncture, or crush drums. These techniques will include probing with a rod and geophysical methods.
- When located, drums should be hand-excavated (See photo 1).
- Liquid from any source, including ground water seepage, should not be allowed to combine with liquid material contained in any excavated drum.
- Pumps used to pump liquids from a buried drum to a new drum must be purged between pumping from different drums.
- Drums that are to receive liquids pumped from buried drums are to be inspected before receiving waste, to ensure that no liquids are already in drum.

On February 24, 1990, drum excavation in Area D was completed. A total of 102 liquid filled drums were excavated from Area D. These drums were staged onsite and eventually incinerated at an off-site facility. Many solid filled or crushed drums were excavated, and approximately 2600 yd^3 of soil were excavated from area D. Backfilling of the area was completed between March 1 and March 3, 1990. Empty drums were crushed and covered in the excavation.

On June 25, 1990, excavation of potentially contaminated soils began in Area C. An area 125 eet by 75 feet with a depth ranging from 19 feet to 26 feet was eventually excavated.

During Area C excavation two large areas of buried drums were unexpectedly encountered on the southern edge of the area. Between July 20 and August 9, 1990, a total of 142 liquid filled drums were excavated without incident, using the modified methods used for drum excavation in Area D. The liquid-filled drums were staged onsite and eventually incinerated off-site. Empty and solid filled drums were re-buried in the excavation.

Slurry Wall Construction

Two slurry walls were constructed. One wall, referred to as the site slurry wall, was constructed to serve as an impermeable barrier between the site and the French drain (See Figures 1 and 3). The site slurry wall has three legs, which parallel the French drain and surround the site from the south, east, and west.

The other slurry wall, referred to as the Area C slurry wall, was constructed around Area C (See Figures 1 and 3) to contain the stabilized soils from Areas C and D. It has three sides, with the fourth side being the site slurry wall.

Prior to construction of the slurry walls, the ability of the slurry wall material to act as a barrier to site-related contaminants was tested. It was required that the wall have a permeability of less than 1×10^{-7} cm/sec for site-related contaminants. The test required that the water/bentonite/soil mixture be tested for permeability using a leachate solution representative of the site. Five pore volumes of the leachate solution containing a total contaminant concentration of 1000 ppm (containing equal proportions of toluene, xylene, methylene chloride and trichloroethylene) were passed through a sample of the slurry mixture. This procedure, which required approximately 2 months to complete, confirmed that the wall had an average permeability of 4.6×10^{-8} cm/sec.

Both slurry walls had the same specifications. These specifications were, in general, standard specifications for slurry walls. In order to ensure compliance with the specifications, tests were performed on the slurry wall materials, on a regular basis. Some of the specifications are described below:

- The slurry walls were built to have a minimum vertical wall thickness of 30 inches (See Figure 4).

- The slurry wall trenches were dug to a depth of backhoe refusal, rather than 3 ft into the weathered shale as originally planned. The original procedure was felt to be imprecise as the shale weathers completely. Excavating to backhoe refusal ensured that the bedrock was reached. While this required additional excavation, it was believed to result in a superior slurry wall.

- The water/bentonite mix had to meet the following specifications prior to mixing with soil:

  - Density = 64 to 85 lb/ft^3
  - Marsh Viscosity $\geq$ 40 seconds
  - Max Filtrate loss = 30 cm^3/30 minutes @ 100 lb/in^2

- The water/bentonite/soil mixture that was placed into the trench to form the slurry wall must have a final permeability of no more than 1×10^{-7} cm/sec.

Construction of the site slurry wall began on March 13, 1990. The first slurry was mixed using water from an existing onsite well. However, slurry mixing was delayed due to low flow from the well. To correct this problem, a frac tank was placed next to the slurry mixing pits. The tank was used to

store water, and it was filled at night and during slack periods from the same onsite well. Water from the tank was then drained directly into mixing pits, as needed.

The site slurry wall was installed in three separate segments. The first leg of the site slurry wall was started at Pt. 5 (See Figures 3 and 4). A starter trench with a 1 in 4 slope began this leg, and the slurry wall was installed, moving towards Pts. 3 and 4. A small pocket of drums was unexpectedly discovered near Pts. 3 and 4. The drums were removed and the excavation was backfilled with clean compacted soil. The slurry wall was then completed to the site's southwestern corner, at Pt. 3.

The second leg of the site slurry wall was started on the northwestern extremity of the site, at Pt. 2, and progressed towards Pt. 3. The slurry wall had been installed only a short distance when the trenching unexpectedly encountered a part of the abandoned landfill. The work was halted and a decision was made to excavate the landfill debris and bury it under the cap within the site slurry wall. This excavation was then backfilled with clean, compacted material.

In order to minimize the delay in completing the site slurry wall, construction of the third leg began while the landfill debris along the second leg, was being excavated. Construction of the third leg began at Pt. 6 and was completed upon reaching Pt. 5. Construction was then resumed on the second leg. The entire site slurry wall was completed on March 11, 1990, when the second leg was completed at Pt. 3.

In total, the site slurry wall had an approximate length of 1400 feet and required approximately 1741 yd^3 of the water/bentonite slurry.

Construction of the Area C slurry wall commenced on September 18, 1990, and was completed without unexpected events on September 20, 1990. The Area C slurry wall was approximately 465 feet long and required approximately 726 yd^3 of the water/bentonite slurry (See Figures 3, 6, and 7).

French Drain

The French drain was constructed 10 to 20 ft upgradient from and parallel to the site slurry wall (See Figures 3, 5, and 5b). The purpose of this drain is to intercept upgradient, clean, ground water and detour it around the site. The French drain consists of a highly permeable, gravel filled trench with a perforated collection pipe installed along the bottom. The perforated collection pipe was connected to non-perforated pipe on the east and west ends of the system. These pipes carry the collected ground water into two recharge wells. The recharge wells were completed into two empty coal mine voids located immediately north of the site (denoted as Pts. 1 and 6 on Figure 3).

The French drain trenches were dug down into the shale layer so that the drain bottom was keyed into the shale, in accordance with the construction plans. A four-inch perforated pipe was placed in the bottom of the trench and covered with filter sand to within 2 feet from the ground surface. The remaining 2 feet of trench were then filled with compacted backfill.

Just south of Pt. 6, along the eastern side of the site, it was known that the French drain would cross the abandoned landfill (See figure 5). To avoid settling of the landfil beneath the French drain, and subsequent damage to the system, a gravel bridge was planned and constructed across the landfill. This bridge was constructed before installation of the French drain began. In constructing the bridge, the landfill debris was removed down to bedrock. The excavation was partially filled with gravel and then filled with compacted backsoil up to the elevation of the perforated piping.

In order to avoid contaminating the clean ground water that is being diverted around the site, with leachate from the landfill, the perforated pipe was enclosed in a solid pipe as it crossed the landfill. Once the piping was laid, compacted backfill was placed over the piping.

Construction of the French drain system began with the installation of the mine void recharge manway at the northeast end of the site (Pt. 6). This recharge well was completed on April 30, 1990.

A French drain trencher was then used to lay the French drain piping and filter sand. Installation began at the northeast corner of the site and progressed around the site towards Pt. 5. In the middle of the southeast side of the site, the rock became too shallow for the trencher to operate. The remainder of the southeast side of the drain to the highest point was installed using a sewer box and backhoe method.

A small pocket of drums was unexpectedly encountered where the drain turns northwest on the southern perimeter (See Figure 3). A clay plug was installed on the French drain pipe to prevent contamination of the pipe, while the drums were removed. Once the drums were removed, installation of the drain proceeded. Drain construction was completed on June 15, 1990.

Soils Stabilization/Solidification Pilot Study

The selected remedy required that the contaminants in soils be immobilized through a stabilization process.

Stabilization is a widely accepted practice for immobilizing metals in soils and sludges. Recently, interest has grown in stabilizing organics. Soundararajan, Barth and Gibbons (1990) experimented with the use of organophilic clay to stabilize waste containing organic compounds. Waste samples from a recycling facility in northern Florida containing naphthalene, phenanthrene, and benzo-a-anthracene were stabilized using synthetic organic clay. Using several sophisticated analytical techniques, it was shown that chemical bonding, not mere absorption, occurred between the clay and the organic contaminants.

Caldwell, Cote and Chao (1990) experimented with different cement-based additives to stabilize wastes with organic contaminants. Included in their study were monocyclic aromatic compounds including benzene, toluene, and orthoxylene (all were priority pollutants at the IWC site). Caldwell, et al concluded that chemical containment of organic compounds is possible, but is highly contaminant dependent.

Bench scale studies conducted for the IWC Steering Committee indicated that Class C flyash (CFA) would be an effective stabilizing agent at the IWC site. However, it was unknown how much CFA should be used, or the curing time that would be required. In order to delineate these important parameters, a pilot study was performed.

A 12 foot by 12 foot area was excavated from Area C to obtain samples for the pilot. Previous sampling from the area had indicated that the northwest corner of area C was most likely to yield the most highly-contaminated soils. Prior to the excavation, the area was preconditioned with CFA to minimize volatile emissions and to ease materials handling of the soils, which oftentimes had a sludge-like consistency. The preconditioned material was stockpiled for the pilot.

Figure 15 shows the test plot for the pilot study. The test plot was 50 feet (E-W) x 80 feet (N-S), subdivided into 5 sections each 16 feet wide. The preconditioned soils (20% CFA was added prior to excavation), which had a total volume of approximately 73 yd^3, were spread over the test plot to

a depth of 6 inches. After removal of debris (small rocks, concrete chunks), the particle size of the soil was reduced by having a Cat SS-250 soil stabilizer make six passes over the test plot.

A front end loader then evenly distributed CFA in measured quantities into the five subsections. CFA was added to each subsection in 20% increments. The first subsection received an additional 20% from that already received prior to excavation (for a total of 40% CFA added), and the last subsection received an additional 100% (for a total of 120% CFA added). After adding a requisite amount of water, each of the five subsections received three passes by the Cat SS-250 for final blending. Following the final blending, a CT-433 sheep's foot compactor was used to compact the material.

After the test plots had cured for 26 days, samples of the stabilized material were taken with a hand-operated coring tool and sent to laboratories for TCLP testing. The tests were conducted after 28 days of curing. The only sample to pass the TCLP test (See Figures 9, 10, 11) for all of the target chemicals (ethylbenzene, toluene, xylene plus metals barium and total chromium) was that sample where a total of 120% CFA had been added.

Samples for the ASTM-2166 Unconfined Compressive Strength Test (UCS) were taken between 2 and 7 days of curing. All samples except one, with 80% CFA (a total of 100% CFA added), failed to pass the 50 psi UCS after 7-day curing (See Figures 12 and 13). However, subsequent bench scale testing indicated that solidification with the addition of 4% Portland cement achieved 90 psi UCS after 7-day curing. Blends with 8 and 12% cement attained higher compressive strengths (See Figure 14).

Based upon the results of this study, it was concluded that in order to meet both the TCLP and compressive strength requirements, a total of 120% CFA should be used in conjunction with 4% Portland cement. It was further concluded that the curing time was somewhere between 0 and 28 days.

Soils Stabilization/Solidification

Prior to beginning the full-scale stabilization process, a one-foot thick clay liner was added to the floor of Area C excavation, to serve as a leachate barrier. Mixing pads were also constructed near Area C, east of the Soil Staging Facility.

On June 25, 1990, the full-scale soil stabilization/solidification phase began. A total of seven lifts were each treated with 120% CFA and mixed on the pads near Area C. An adequate amount of water was mixed in, and each lift was allowed to cure.

While the first pad was curing, daily samples were taken to test for the TCLP target compounds, benzene, ethylbenzene, toluene, xylene, using a field GC/MS. Samples were also sent off-site every few days to a laboratory for TCLP analysis. From the results, a correlation between the target compounds, as analyzed using the field GC/MS, and the laboratory TCLP results, was developed. This correlation was then used to predict when to perform the required TCLP analyses, based upon the less expensive field GC/MS results.

The first stabilized pad passed the TCLP test in 17 days. For subsequent pads, the curing time required to pass the TCLP test varied from 11 days to 17 days.

When the first lift passed the TCLP test it was taken into Area C for in-situ solidification, using 4% Portland cement. On August 23, 1990, this first lift of stabilized/solidified material unexpectedly failed the 7-day 50 psi UCS criterion. The lift was broken up using a disc and bulldozer and

repulverized using an SS 250 mixer. An additional 8% cement was added to the lift. On August 27 the re-cemented lift attained a compressive strength of 125 psi in 3 days and passed the UCS criteria.

Subsequent lifts passing the TCLP criteria on the mixing pads were brought to Area C and spread over the previously solidified material. These lifts were solidified in-situ by mixing 8% cement, and all passed the UCS criteria in less than 7 days.

Soil stabilization/solidification was successfully completed on September 10, 1990. Approximately 12,800 yd^3 of soil was excavated, of which 1800 yd^3 was found to be contaminated, and this was stabilized/solidified.

RCRA Cap & Cover

The RCRA cap and cover was installed to prevent surface infiltration, which could cause leaching of the buried waste. The cap and cover was installed over the majority of the site including Areas B, C and D (See Figures 1 and 3).

The cover system consists of a 2-foot clay layer overlaid by a high density plastic liner (HDPE liner). A one-foot sand drainage layer covers the HDPE liner. This layer is covered with geotextile filter fabric. The geotextile fabric is covered with 1.5 feet of compacted backfill. Six inches of top soil is spread over the entire cap. Along the toe of the cap, a geogrid and gravel drain wedge is installed. (See Figures 8 and 8b).

During the cap construction, two small areas of landfill trash were discovered on the north edge of the cap outside the boundaries of the original cap. The first area in the northeast was discovered early during installation of utilities. The second area of trash was found while digging the anchor trench. Specifications of the cap were changed to enclose this area under the cap boundary.

Preliminary work on cover installation started before Area C solidification was complete. The contractor started to move, compact and grade the general site backfill on August 23, 1990.

The installation of the 2-foot clay layer started on the east end of the site on September 17, 1990. The clay was compacted in four lifts, each about six inches thick. Moisture and density tests were conducted to ensure proper compaction. The cap was maintained prior to the installation of the liner by scarifying and wetting, as necessary, and by rerolling and fine grading. The clay cap was completed by October 17, 1990.

Installation of the 60 mil HDPE liner started on October 11, 1990, while the clay layer was still being completed. Before laying each piece of the liner, the portion of the clay cap to be covered, was inspected to ensure that the liner would not be damaged by underlying material. Panels of the HDPE were unrolled and cut to the approximate length and shape. The panels were fitted and welded. The panel welds were vacuumed and pressure tested. HDPE boots were fitted over the piezometers and wells and welded to the liner (See Figure 8). The HDPE liner was installed over the entire site by October 30, 1990.

Construction of the geogrid and gravel toe drain was started on October 22, 1990. A 2 inch by 12 inch form was placed between the toe drain and the sand drainage layer. This form was removed after sand and gravel were installed (See Figure 8b). Geogrid installation was complete by November 3, 1990.

The sand drainage layer was started on October 18, 1990. Sand was delivered to the east end of the site and pushed over the HDPE liner using a low ground pressure dozer. As the front of the sand

progressed across the site crane mats were used to support dump trucks delivering sand. The sand drainage layer was completed on November 9, 1990.

The geotextile filter fabric was then installed over the sand drainage layer to prevent fines from the overlying soil backfill from permeating into the sand layer.

The first backfill layer was placed and compacted on October 31, 1990. The first lift of the backfill was one-foot thick before being compacted. The second lift brought the backfill to the required compacted thickness of one-and-a-half feet. The last of the backfill was placed on November 29, 1990.

Following completion of the backfill, a topsoil layer was lightly compacted over the entire cap to a minimum depth of six inches. Placing of the top soil started on November 19, 1990. The surface was hydromulched between December 12 and 14, 1990 to start the vegetative cover. Erosion control fabric was placed on the side slopes of the cap to prevent excessive water flowing off the cap. The cap and cover installation was complete on December 14, 1990.

CONCLUSIONS

Remedial construction at the IWC site involved a wide range of activities. Contaminated soils, trash, and buried drums containing liquid hazardous wastes, were excavated from landfill areas. Two slurry walls were constructed, as was a French drain that included two recharge wells. Contaminated soils were stabilized and solidified following a pilot study. A RCRA cap was also constructed. All of these tasks were successfully completed. Overall, the remedial construction was completed ahead of schedule and well within the estimated costs.

Because very few remedial construction projects have been completed nationwide, it is important that those projects that have been completed, serve as learning tools for future projects. While this project was successfully completed, some important lessons were learned.

The following is a summary of the lessons learned at the IWC site:

- It is extremely difficult, but very important, to accurately define the locations of landfill debris, as well as the locations and number of buried drums. This is difficult because, usually, very few landfill operating records are available, and because investigations using boring techniques oftentimes miss large areas of buried debris or drums. It is recommended that remedial investigations at landfill sites include the use of ground-penetrating radar which is capable of locating 55-gallon drums at depths of 6 to 9 feet, as well as investigative trenching techniques.

  Throughout the IWC construction phase, the importance of accurately defining the locations and number of buried debris and drums was illustrated. Landfill debris was unexpectedly encountered during construction of both the site slurry wall and the RCRA cap. While this only resulted in minor delays and minor modifications to the construction plans, more significant delays could result at different projects.

  In addition, far fewer buried drums were found in Area D, than had been estimated, and buried drums were unexpectedly encountered while excavating contaminated soil in Area C. It had been estimated that as many as 3000 liquid-filled buried drums may exist in Area D, but only 102 were found. Conversely, buried drums were not expected in Area C, and 142 liquid-filled drums were found. While finding far fewer drums in Area D did not disrupt the

project, unexpectedly finding drums in Area C did. Installation of the French drain system was also disrupted when buried drums were unexpectedly discovered.

- Excavation of buried drums is both difficult and dangerous. Buried drums tend to be in various stages of disintegration and can spill their contents with the slightest disturbance. Oftentimes, in order to minimize the release of a drum's contents, it is necessary to either hand-excavate the drum and/or pump its contents to a new drum. The drum explosion demonstrated how dangerous drum removal can be. Great care must be taken to minimize the commingling of different materials within an excavtion. This obviously includes minimizing the flow of ground water into an excavation. In addition, it is imperative that the excavation crew constantly watch for signs of an unexpected reaction.

- Construction plans must ensure that enough water is always available. Onsite wells may not be capable of continually supplying enough water as it is needed, particularly during peak construction periods. It may be necessary, especially in rural settings, to store water onsite to ensure its availability.

- It is very important that bench scale and pilot studies be conducted to estimate the amount of stabilization and solidification agents needed, as well as the necessary curing times. These tests should attempt to simulate fullscale field implementation as closely as possible. During the IWC pilot, the addition of cement to attain the UCS criteria should have been performed on the mixing pad instead of in a bench scale test in the laboratory. This would have indicated before full scale work began the optimum amount of cement necessary to attain the UCS criteria and avoided having to re-pulverize the first lift.

ACKNOWLEDGEMENTS

We extend our thanks to the IWC Steering Committee for providing relevant information to prepare this paper. Special thanks are due to Mr. William Bowen and Ms. Sherry Spencer of the U.S. Army Corps of Engineers who provided oversight on behalf of U.S. EPA to assure construction quality. Mr. M. S. Ramesh deserves thanks for guiding the IWC project through remedy selection and remedial design.

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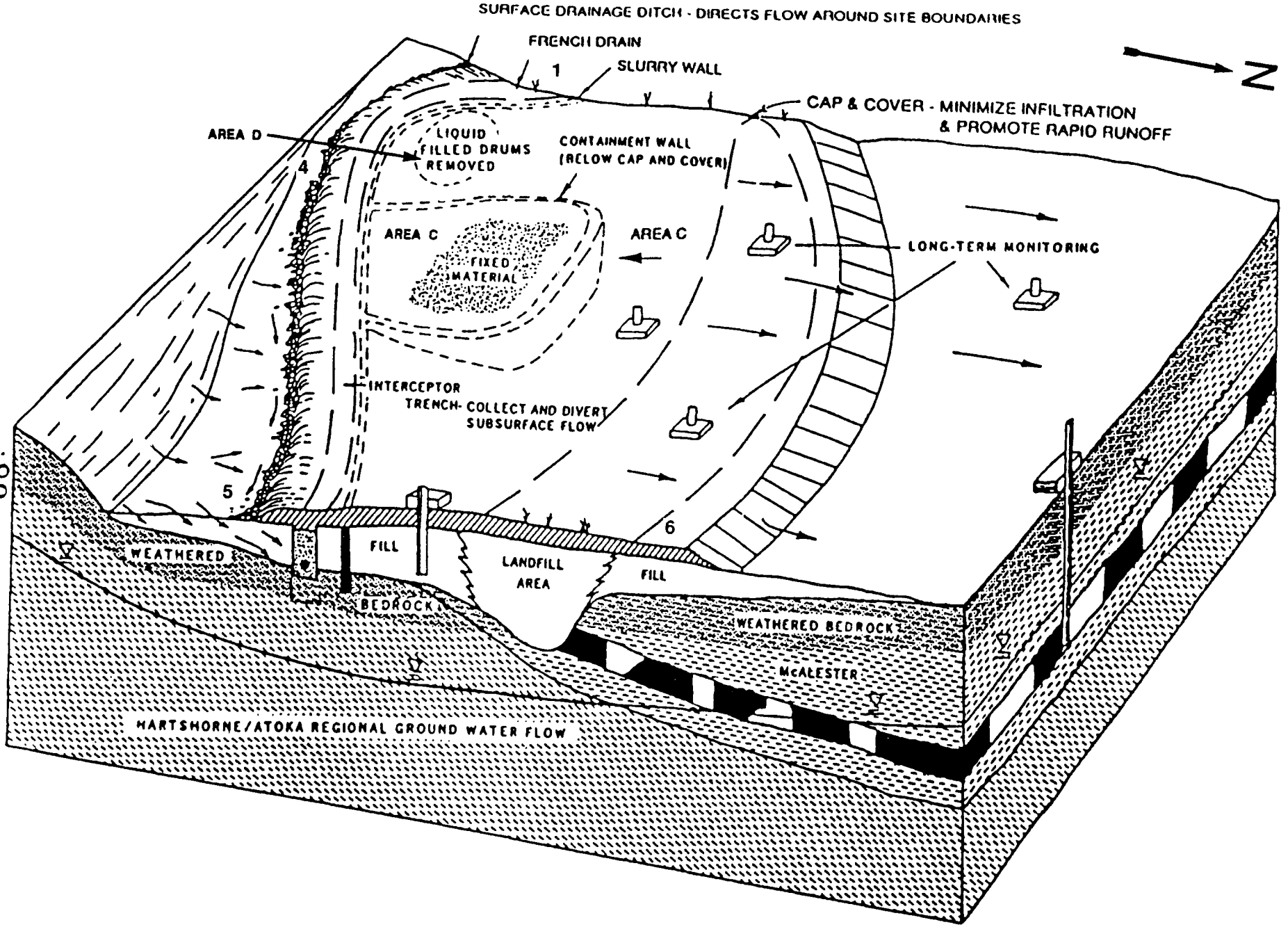
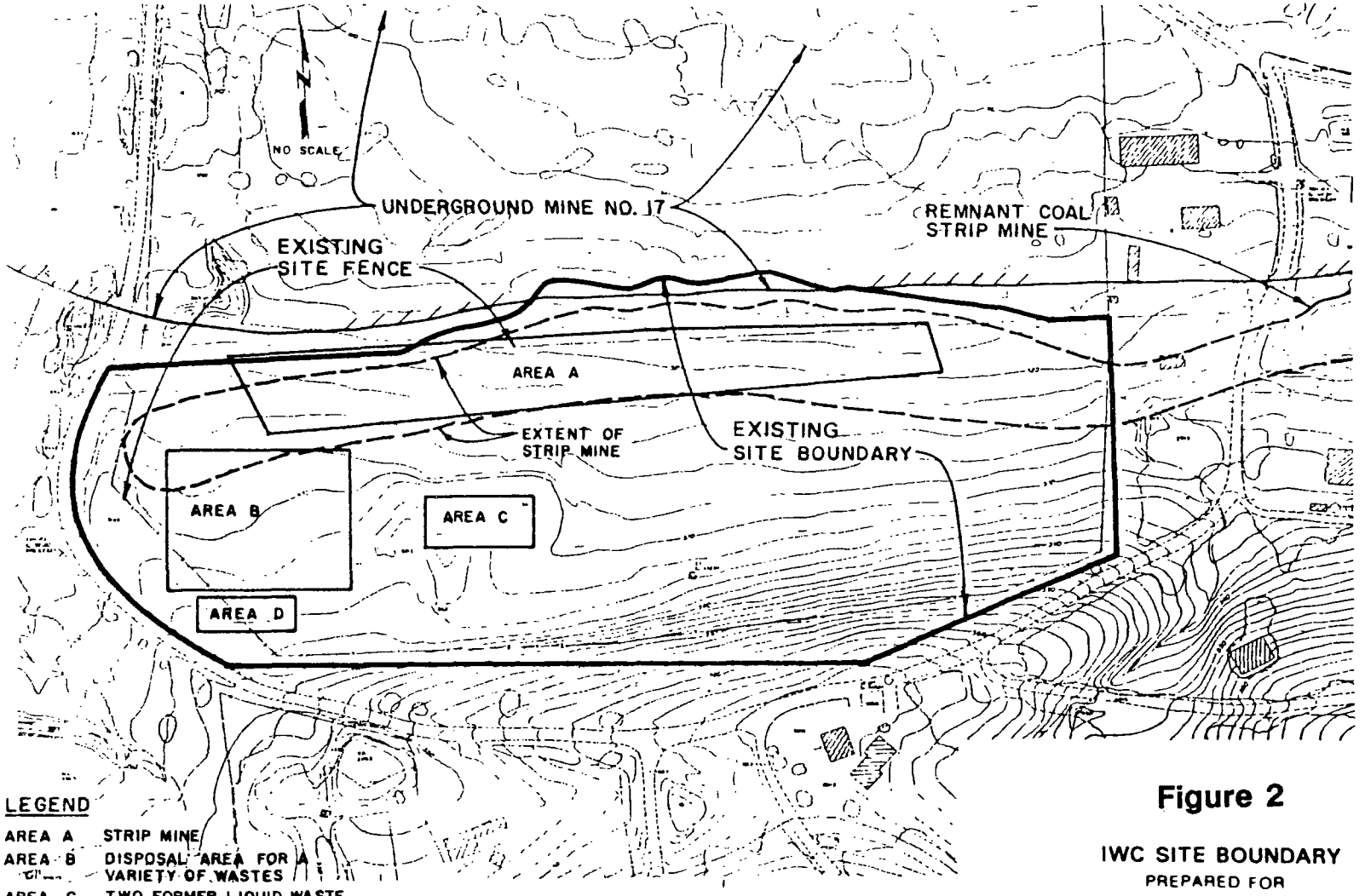


FIGURE 1 - THE REMEDY SELECTED FOR THE IWC SUPERFUND SITE

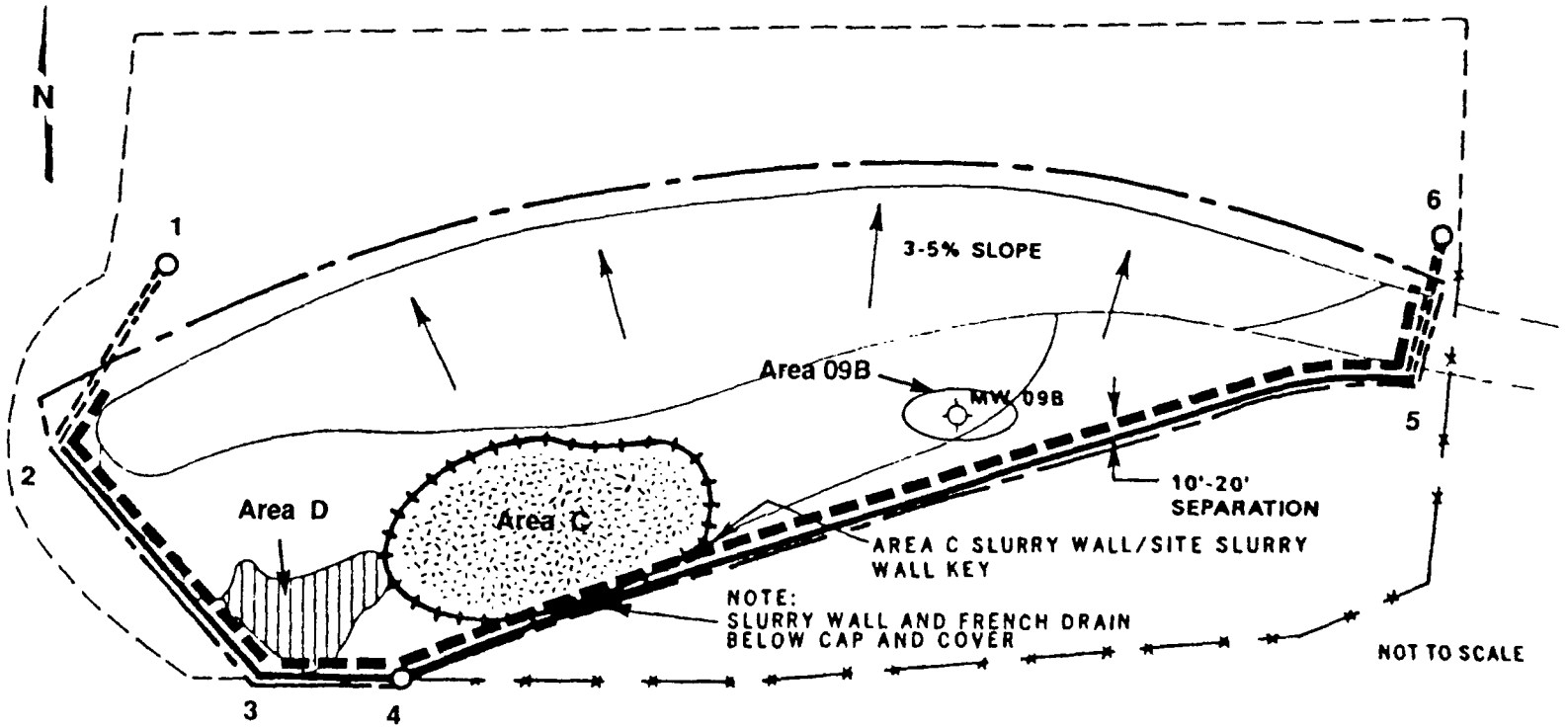


LEGEND

AREA A	STRIP MINE
AREA B	DISPOSAL AREA FOR A VARIETY OF WASTES
AREA C	TWO FORMER LIQUID WASTE SURFACE IMPOUNDMENTS
AREA D	LIQUID FILLED AND CRUSHED DRUM DISPOSAL AREA

Figure 2

IWC SITE BOUNDARY
PREPARED FOR
IWC SETTLING DEFENDANTS
FORT SMITH, ARKANSAS



LEGEND

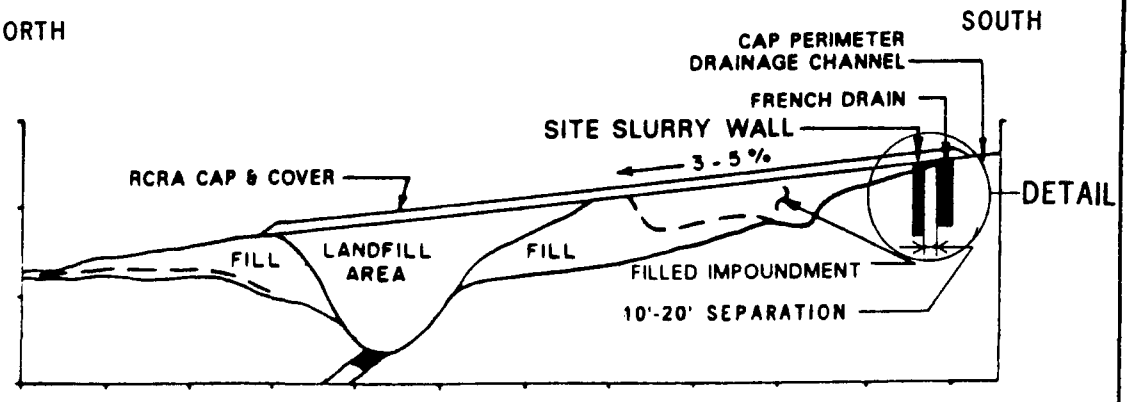
- EXISTING FENCE
- RCRA CAP AND COVER
- PROPOSED EXTENDED BOUNDARY AND NEW FENCE
- AREA C SLURRY WALL
- FRENCH DRAIN
- SITE SLURRY WALL
- DISCHARGE PIPE
- CLEAN BACKFILL
- FIXATED WASTE
- MANHOLE / PIPE DISCHARGE POINT TO MINE

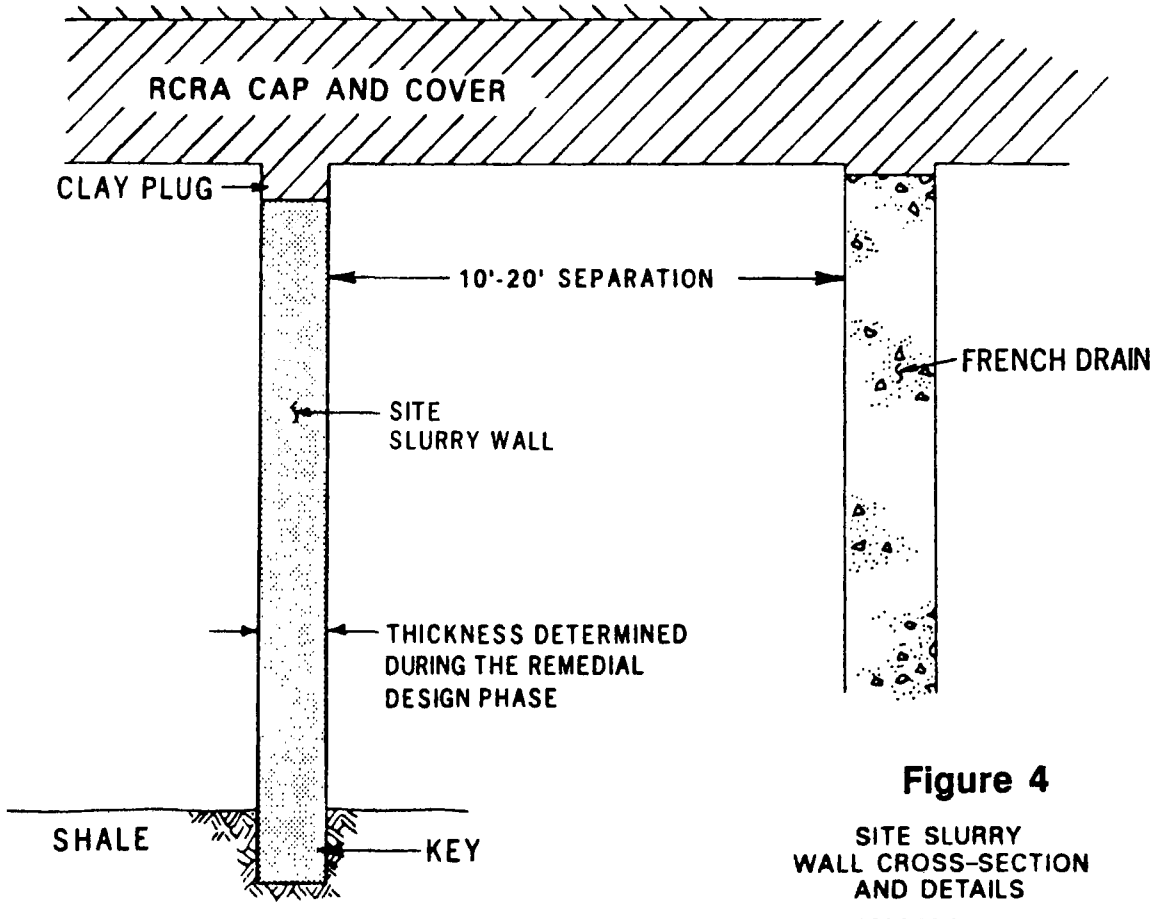
Figure 3

SLURRY WALL,
FRENCH DRAIN,
AND CAP AND COVER
PREPARED FOR
IWC SETTLING DEFENDANTS
FORT SMITH, ARKANSAS

NOTE: MONITOR WELL LOCATION HAS BEEN PLOTTED FROM EXISTING LOG.

TYPICAL CROSS-SECTION
OF SITE SLURRY WALL





SITE SLURRY WALL DETAIL

Figure 4

SITE SLURRY
WALL CROSS-SECTION
AND DETAILS

PREPARED FOR
IWC SETTLING DEFENDANTS
FORT SMITH, ARKANSAS

NOTE: THIS FIGURE IS NOT TO SCALE.

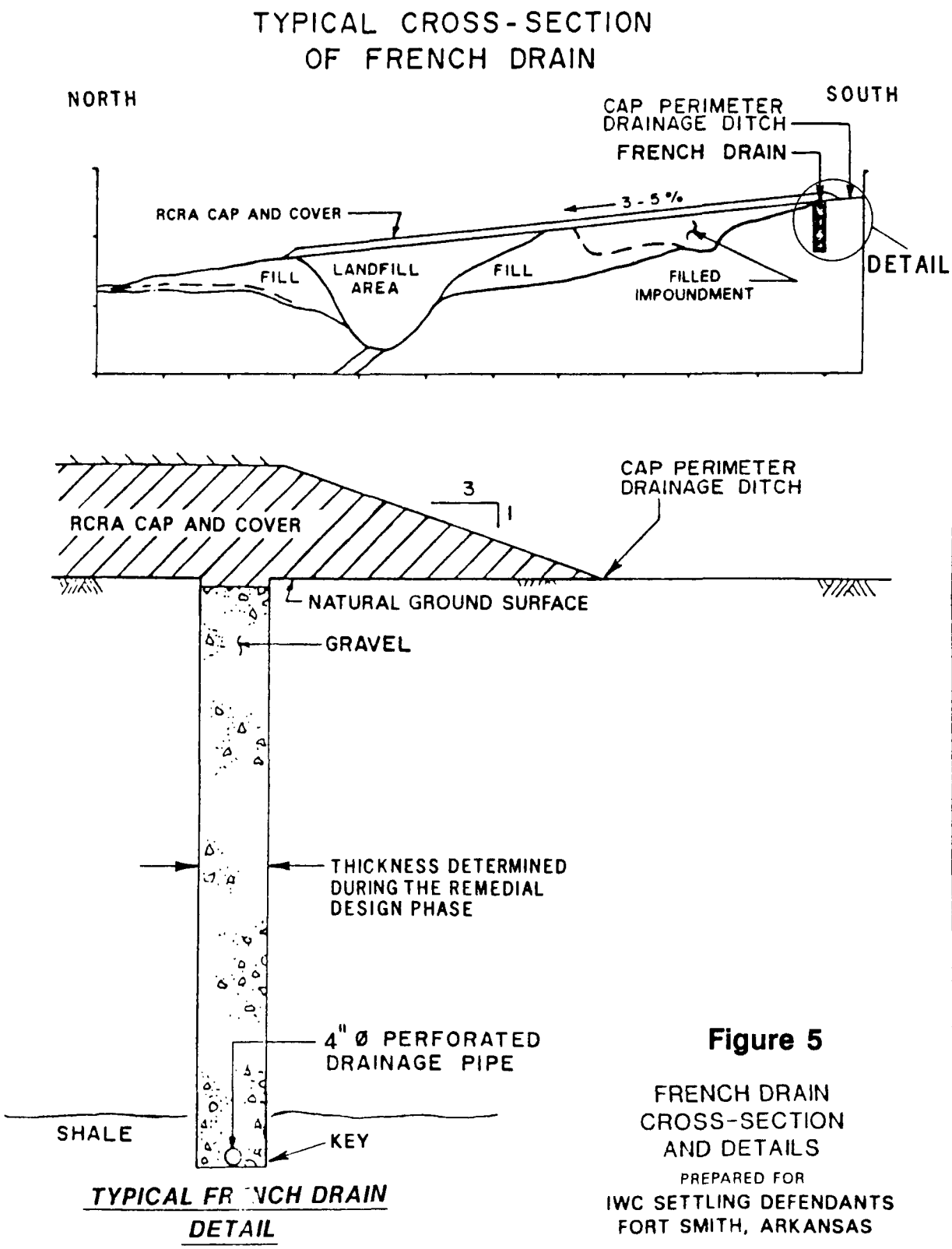


Figure 5

FRENCH DRAIN
CROSS-SECTION
AND DETAILS

PREPARED FOR
IWC SETTLING DEFENDANTS
FORT SMITH, ARKANSAS

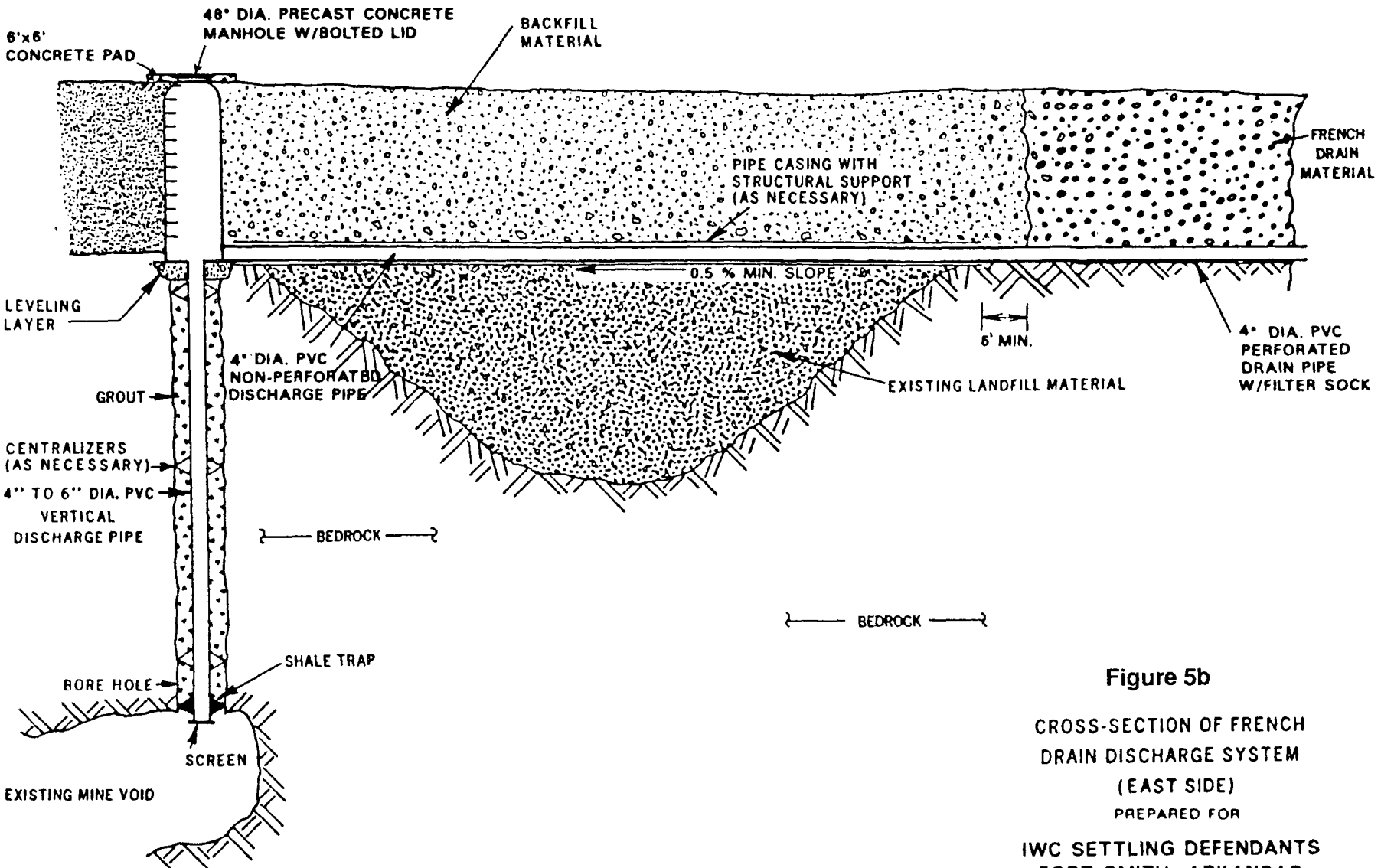


Figure 5b

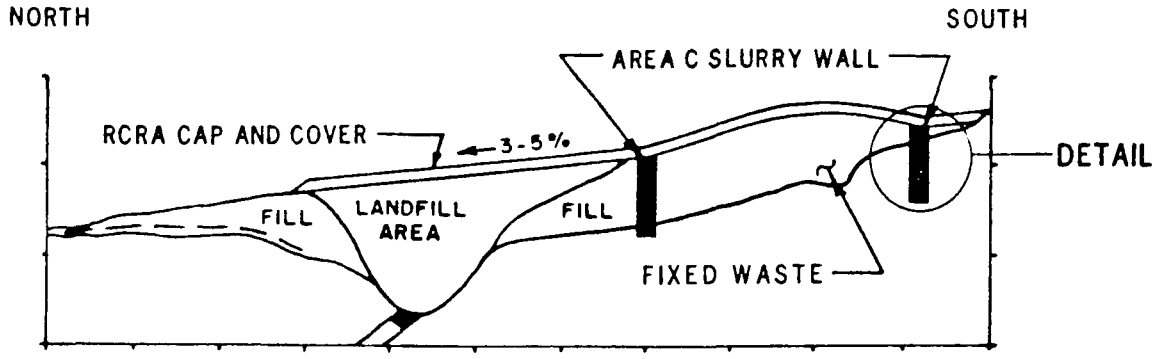
CROSS-SECTION OF FRENCH
DRAIN DISCHARGE SYSTEM
(EAST SIDE)
PREPARED FOR
IWC SETTLING DEFENDANTS
FORT SMITH, ARKANSAS

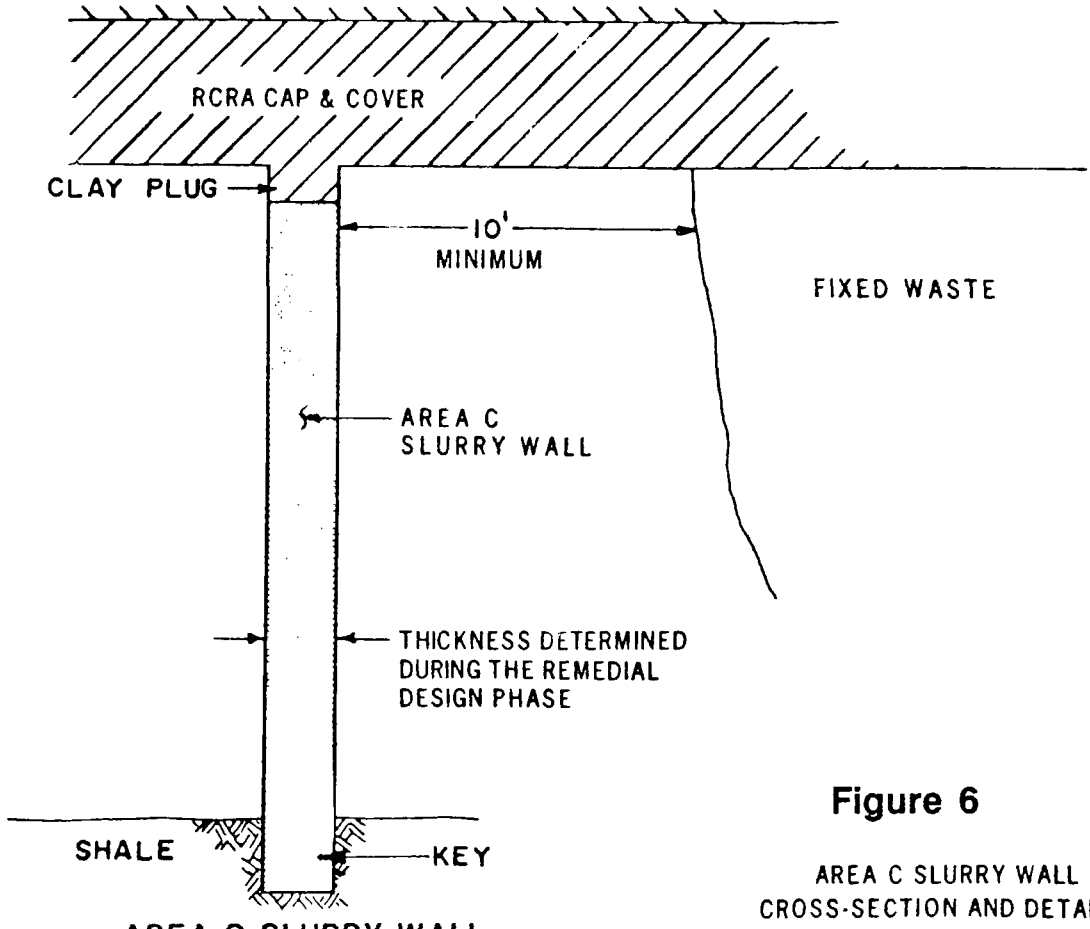
NOTES:

1) THE WEST SIDE CROSS-SECTION WILL BE SIMILAR BUT SHOULD NOT INCLUDE A LANDFILL CROSSING.

2) THIS FIGURE IS NOT TO SCALE.

TYPICAL CROSS-SECTION OF
AREA C SLURRY WALL





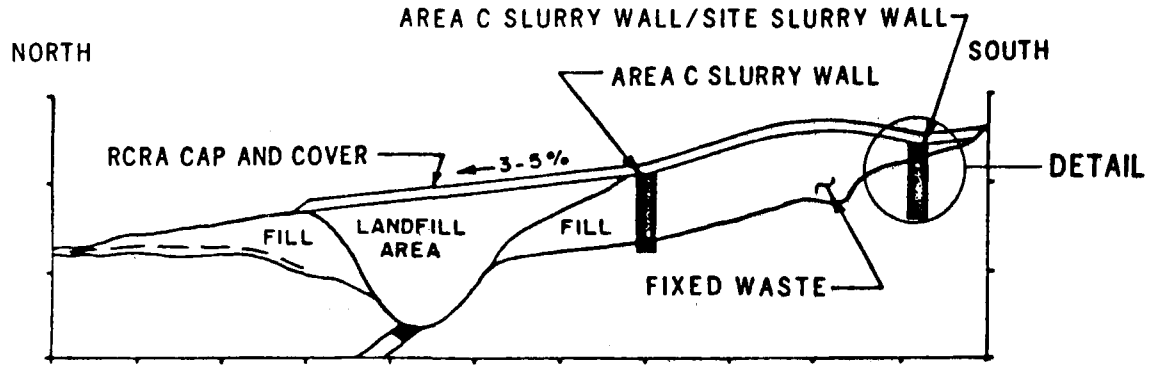
AREA C SLURRY WALL DETAIL

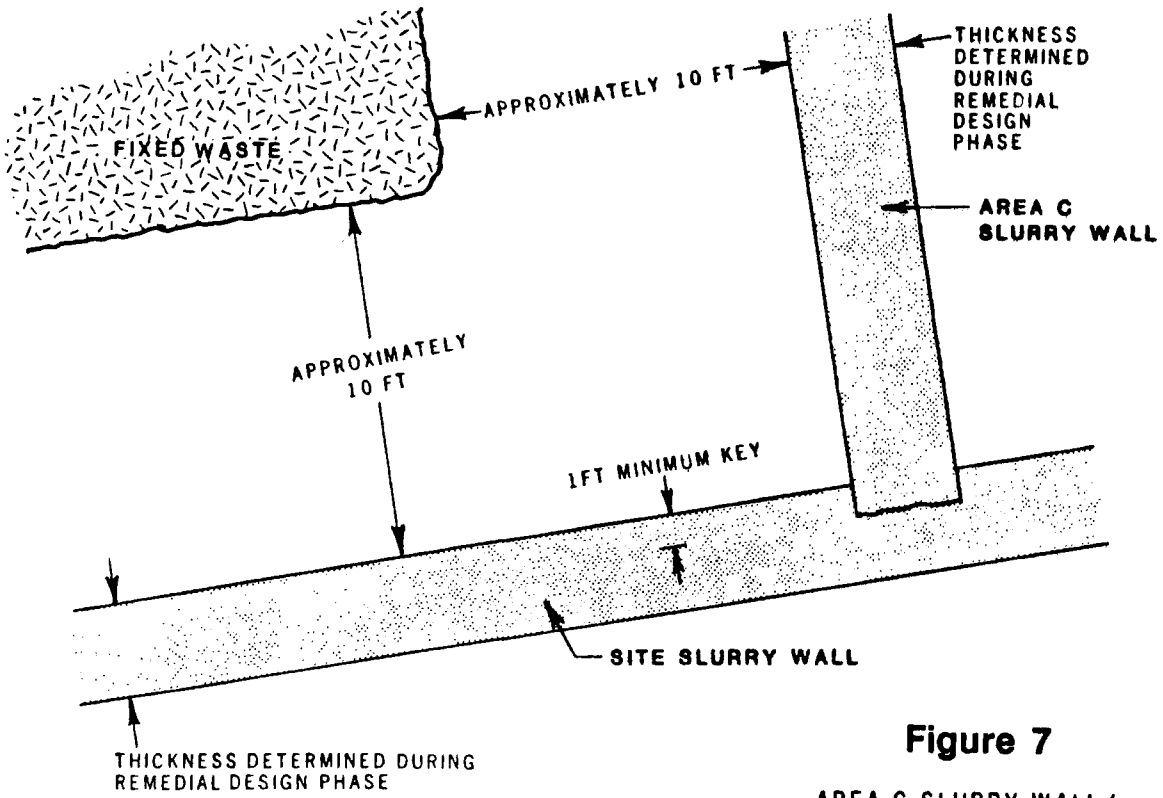
Figure 6

AREA C SLURRY WALL
CROSS-SECTION AND DETAILS
PREPARED FOR
IWC SETTLING DEFENDANTS
FORT SMITH, ARKANSAS

NOTE: THIS FIGURE IS NOT TO SCALE.

TYPICAL CROSS-SECTION OF
AREA C SLURRY WALL/SITE SLURRY WALL KEY





PLAN VIEW OF AREA C SLURRY WALL/ SITE SLURRY WALL KEY DETAIL

Figure 7

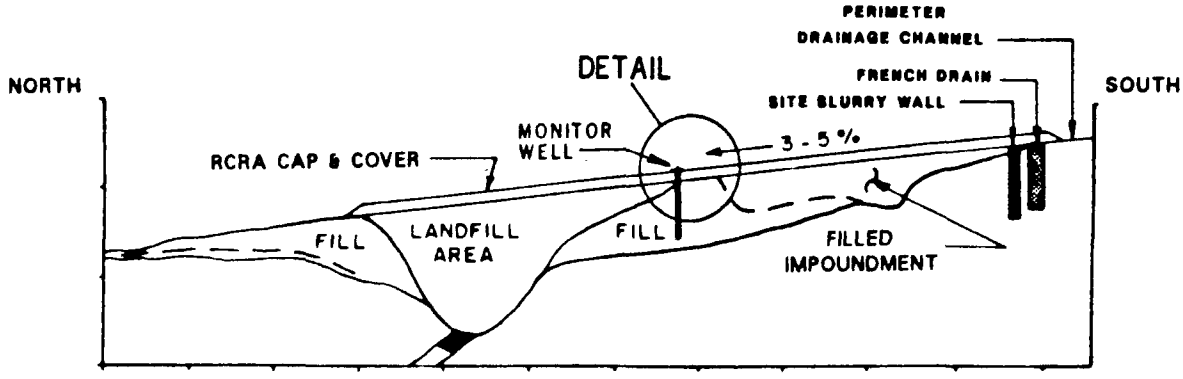
AREA C SLURRY WALL/
SITE SLURRY WALL KEY
CROSS-SECTION AND DETAILS
PREPARED FOR
IWC SETTLING DEFENDANTS
FORT SMITH, ARKANSAS

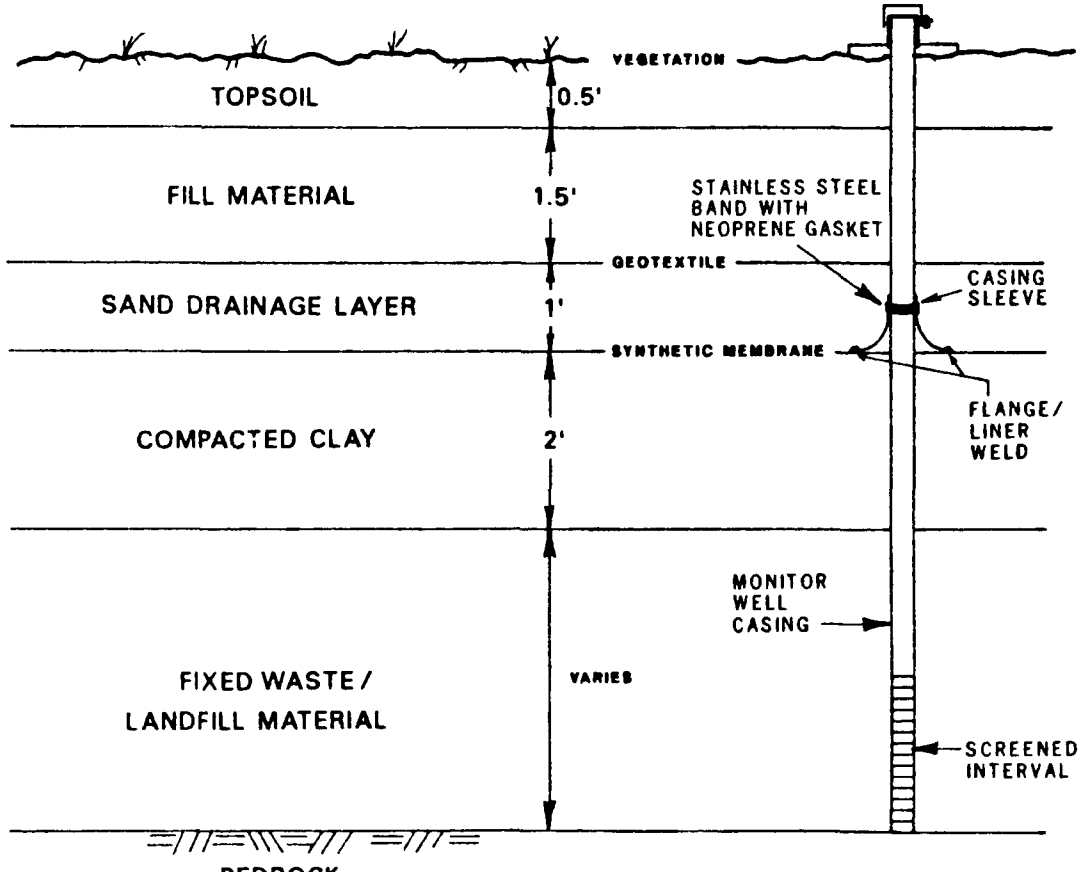
NOTE: THIS FIGURE IS NOT TO SCALE.

131009

Do Not Scale This Drawing

TYPICAL CROSS-SECTION
RCRA CAP AND COVER
AND MONITOR WELL





RCRA CAP AND COVER AND MONITOR WELL DETAIL

Figure 8

RCRA CAP AND COVER
AND TYPICAL MONITOR WELL
CROSS-SECTION AND DETAILS

PREPARED FOR

IWC SETTLING DEFEDANTS
FORT SMITH, ARKANSAS

NOTE: THIS FIGURE IS NOT TO SCALE.

Do Not Scale This Drawing

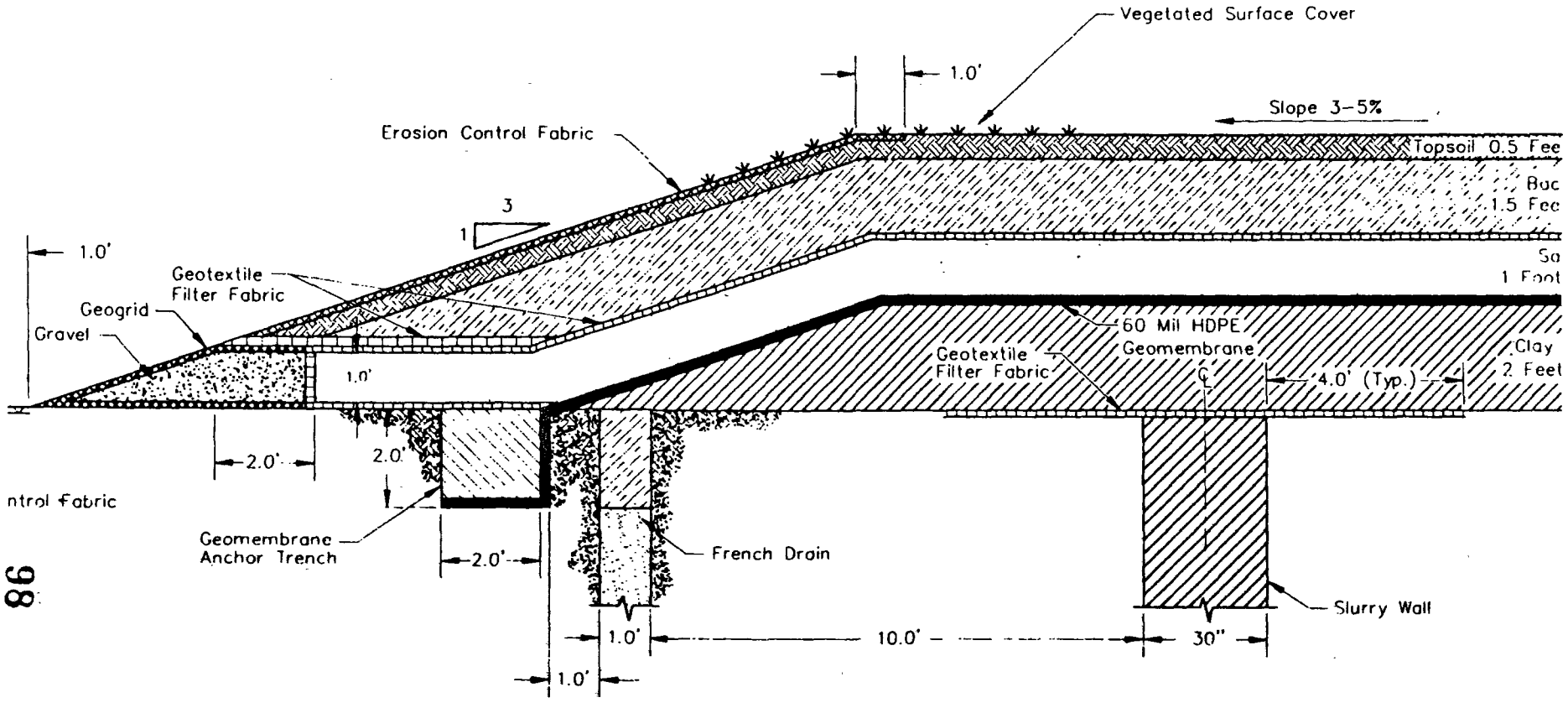


Figure 8b
RCRA Cap & Cover
Cross-section details

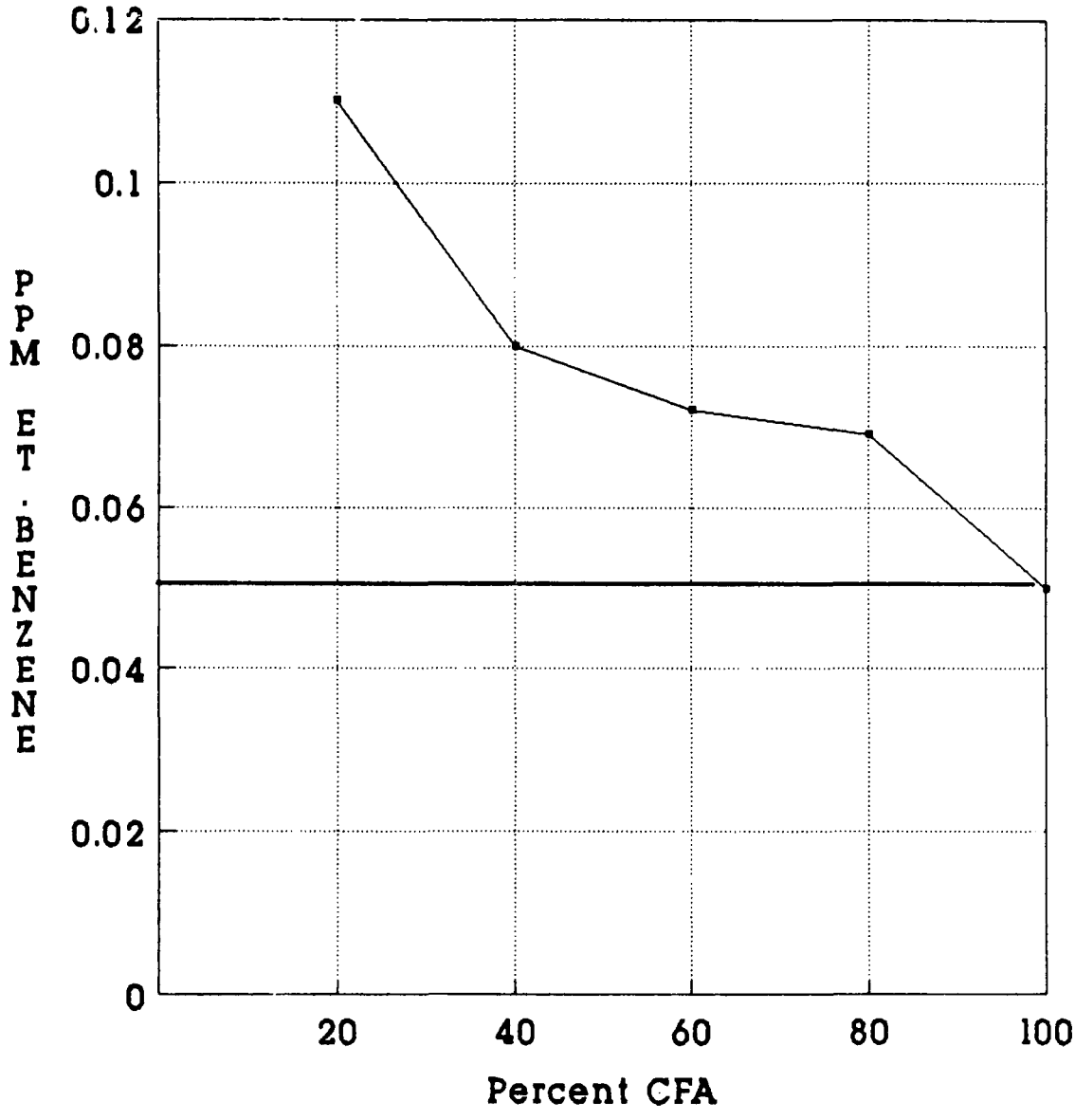


Fig 9

'WC Pilot 28 day cure

TCLP Criteria

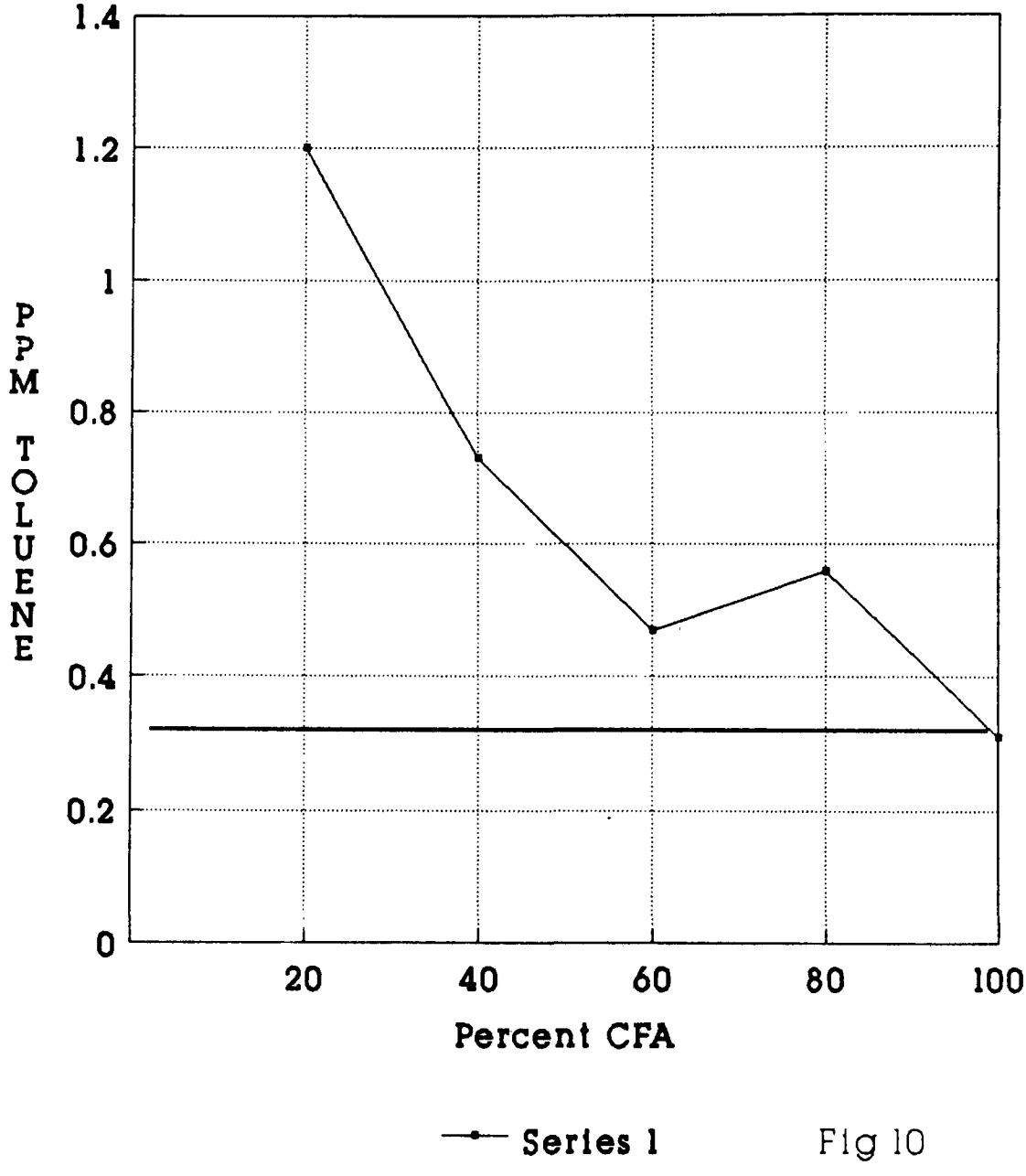
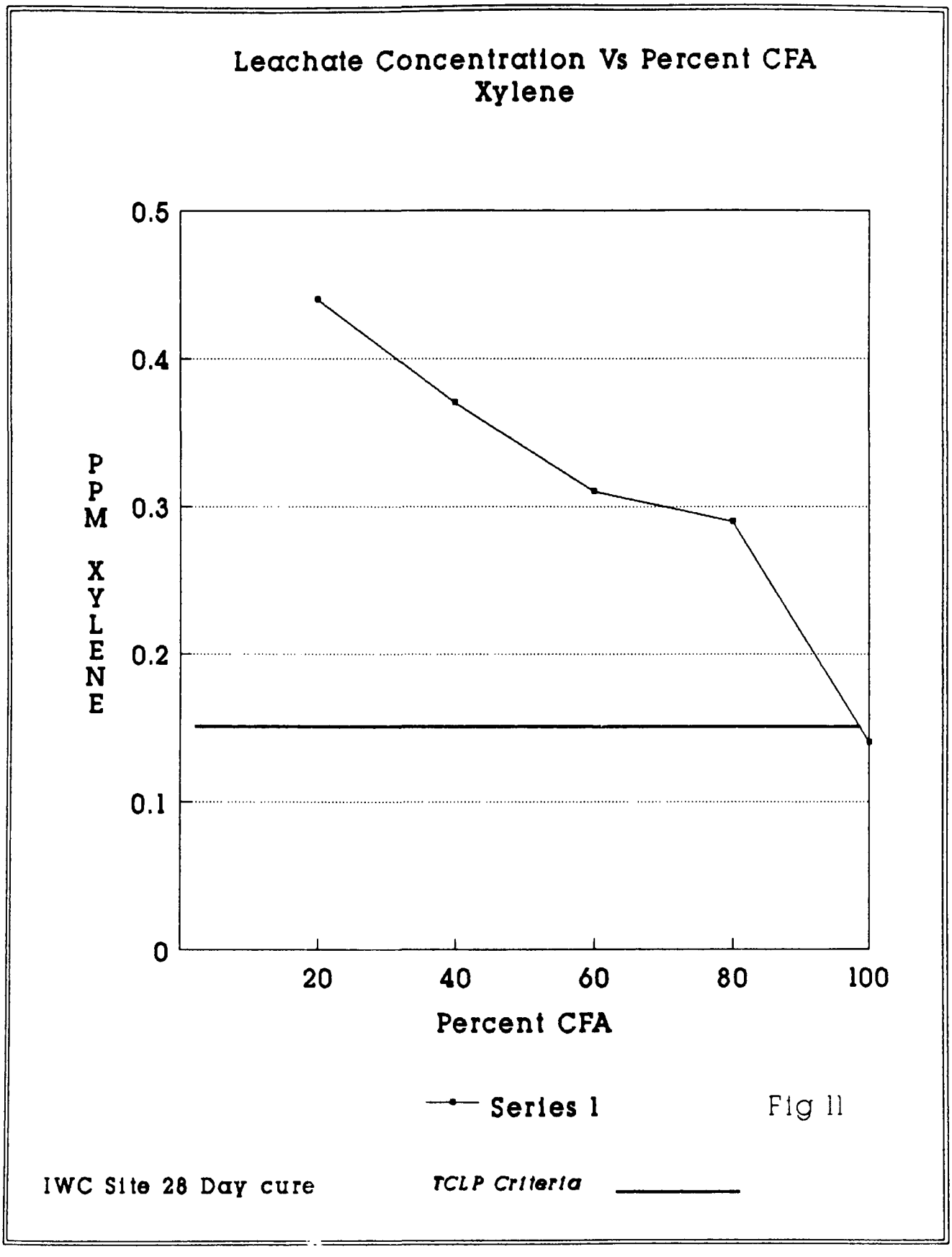


Fig 10

IWC Pilot 28 day cure

TCLP Criteria


Leachate Concentration Vs Percent CFA
Xylene
0.5
0.4
0.3
0.2
0.1
0
PPM XYLENE
20
40
60
80
100
Percent CFA
Series 1
Fig 11
IWC Site 28 Day cure
TCLP Criteria

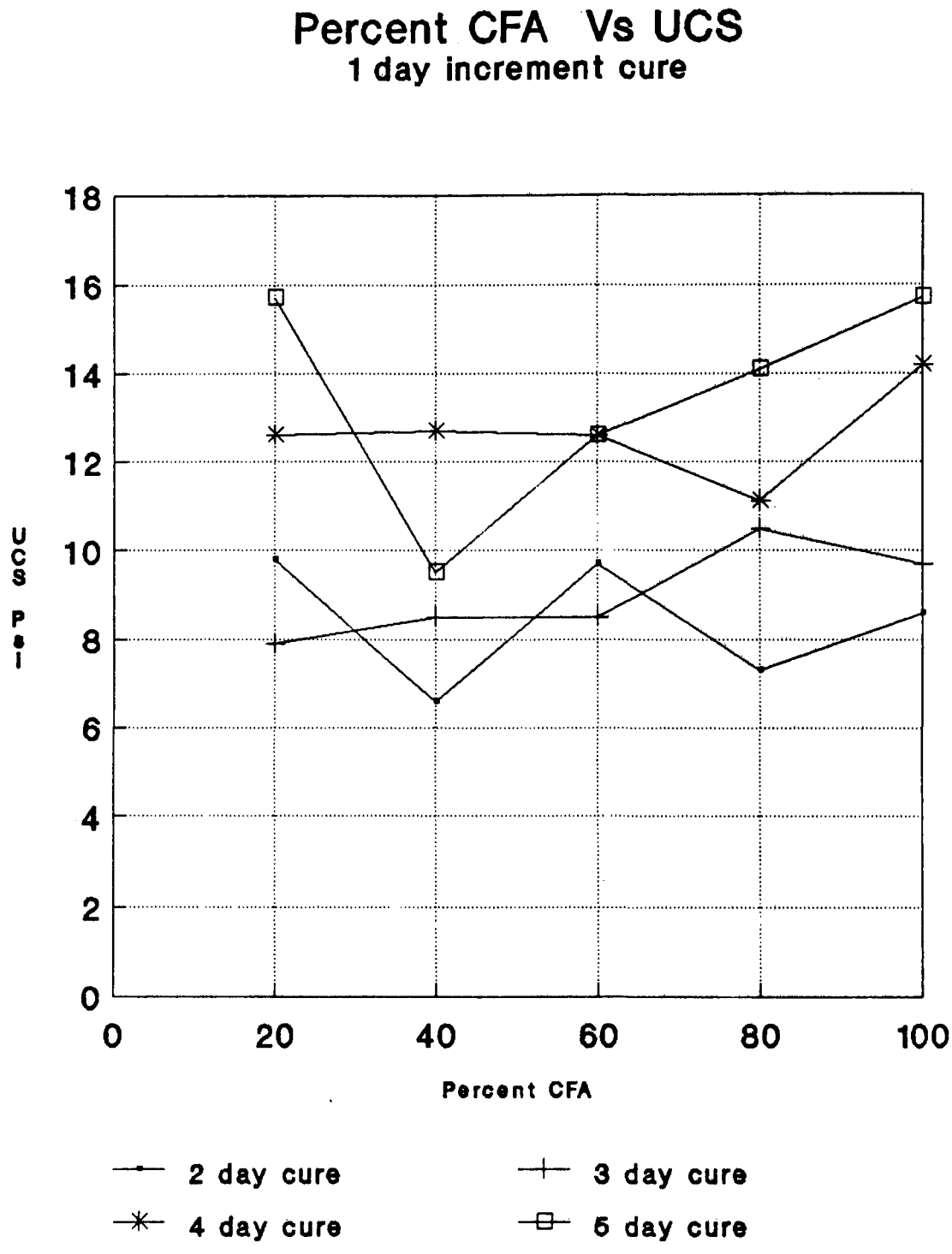
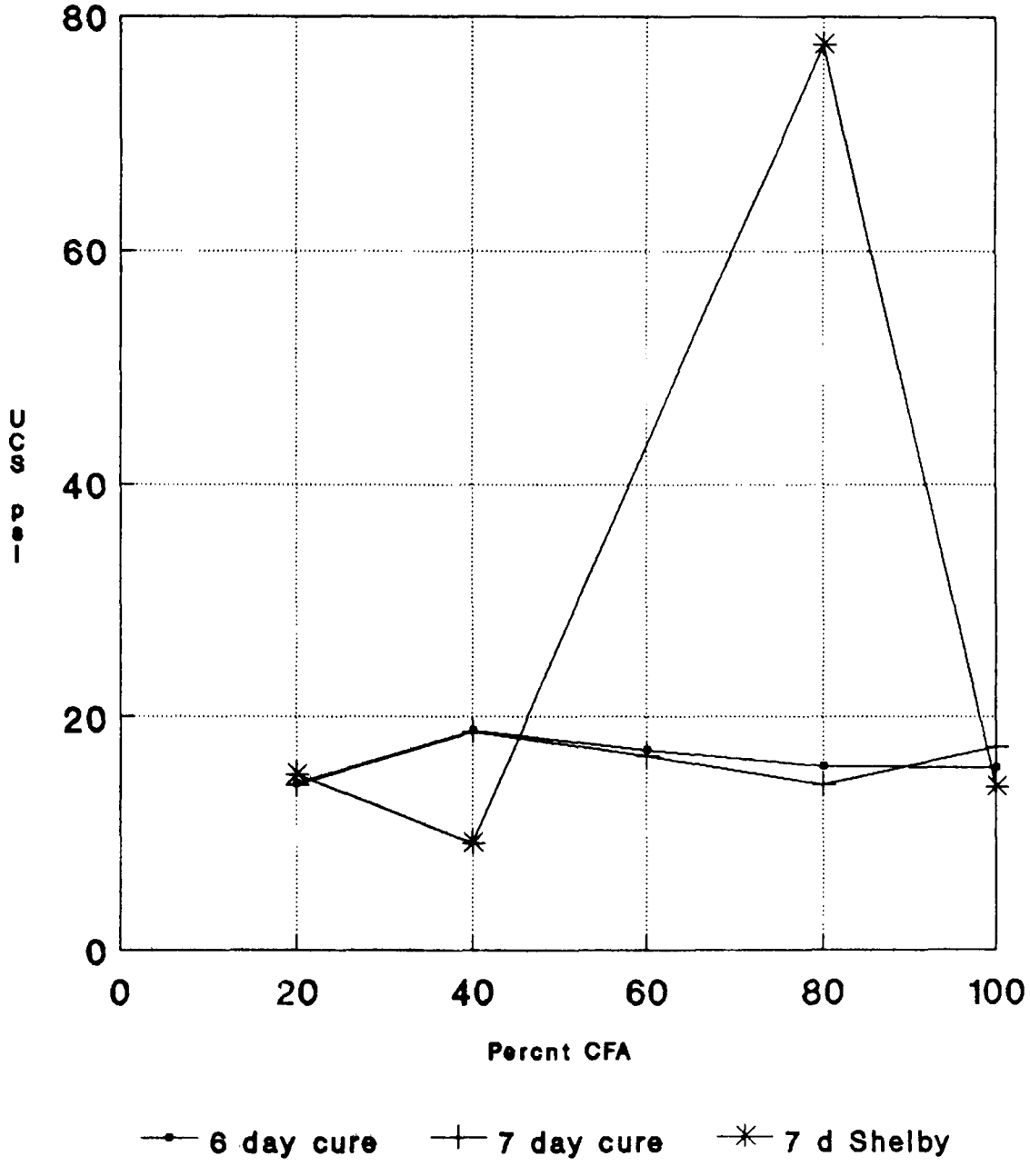


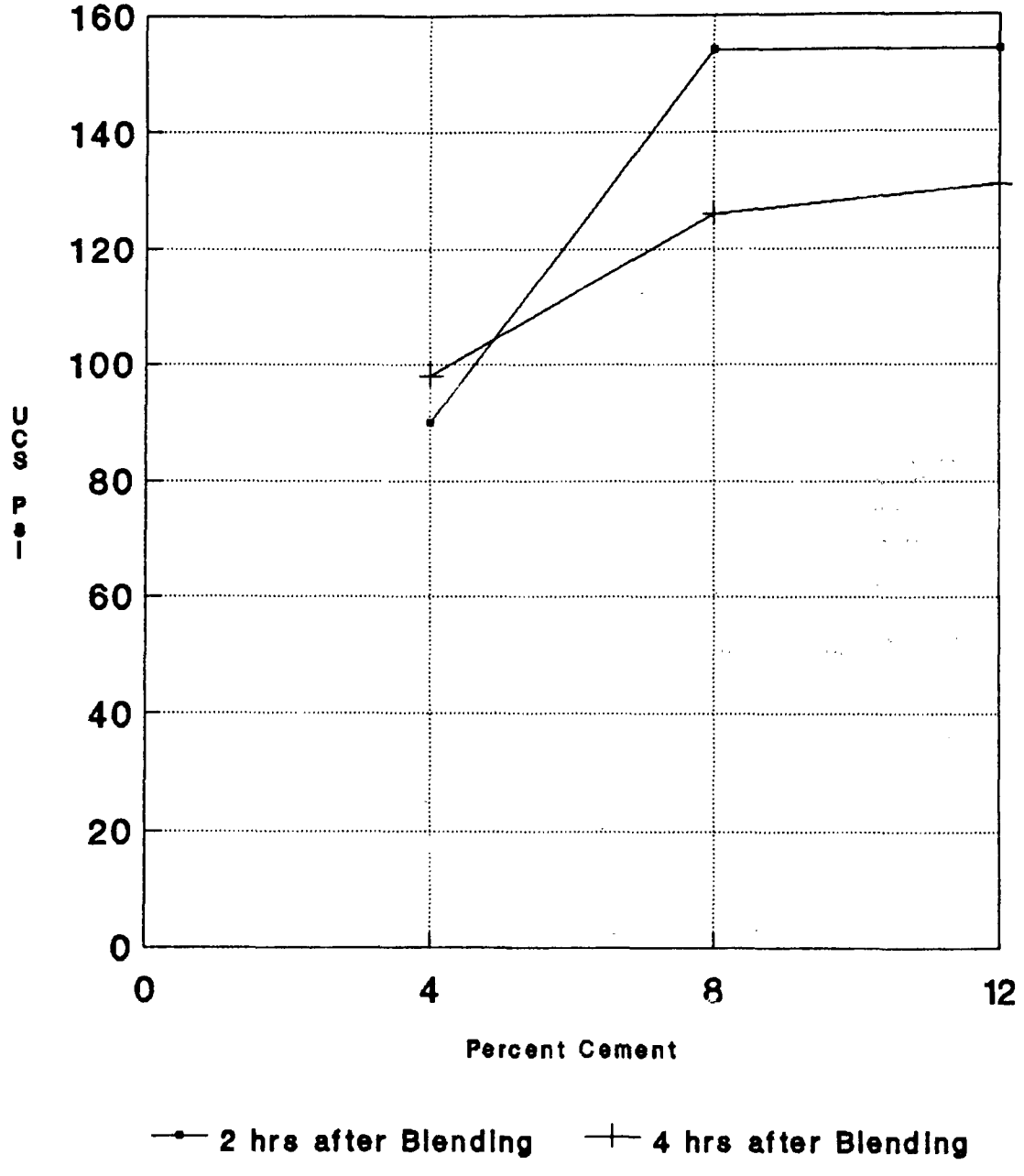
Fig 12

IWC Pilot



IWC Pilot

Fig 13



IWC Pilot

Fig 14

LOCATION OF TEST PLOT

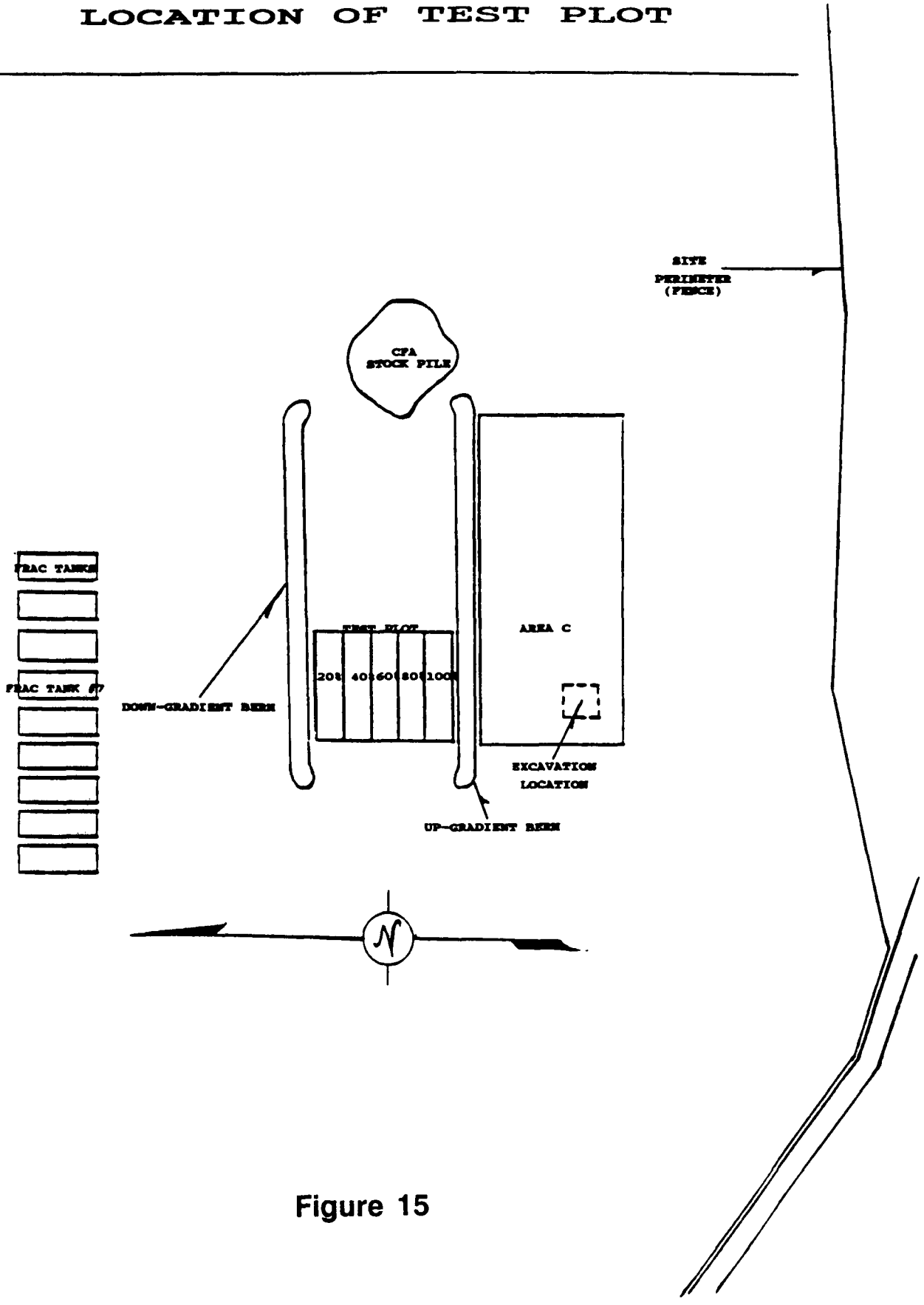


Figure 15

Photo 1 : Drum being dug out by hand, area D

Photo 2 : Pumping liquid from deteriorated drum
in backhoe, area D

Photo 3 : Drum incident, notice tilted drum left of 18. Also notice warped top of the tilted drum

Photo 4 : Tilted drum propelled into air. Notice drum in the horizon above pickup truck.

BAYOU BONFOUCA SUPERFUND SITE
CASE STUDY OF SELECTED ISSUES
Slidell, Louisiana

(Author(s) and Address(es) at end of paper)

I) INTRODUCTION

The Bayou Bonfouca Superfund Site is one of the largest, most complex hazardous waste problems in the country. Cleanup of this site, which will cost in excess of $100 million, is now successfully being implemented after resolution of numerous technical and policy issues. The purpose of this paper is to summarize resolutions to five critical issues which developed during the design. Each of these items threatened to cancel any active remedial response or to render its cost prohibitive. They include:

1) discovery of a threefold volume increase in waste, potentially invalidating the selected remedy;
2) development of a construction management system to prevent fugitive air emissions from threatening residents around the site;
3) adoption of a dry weight payment criteria for the incineration process that potentially affects future incineration projects;
4) funding of such a large project; and
5) bonding requirements to ensure competitive bids.

The authors from the Environmental Protection Agency (EPA) have chosen to provide a relatively brief review of these pertinent issues, thereby giving a broad perspective of the complex challenges involved in large Superfund projects. In addition, this paper allows reviewers to identify possible areas in which they may want to contact the authors for additional information and valuable lessons learned.

II) SITE HISTORY - RECORD OF DECISION

The Bayou Bonfouca Superfund site is located within the city of Slidell, St. Tammany Parish, Louisiana. The site consists of an abandoned creosoting facility on 52 acres of land and an adjacent contaminated bayou for which it is named. The community of Slidell has a population of approximately 26,000 and serves primarily as a bedroom community for New Orleans, which is about 25 miles away. The land use adjacent to the bayou ranges from a industrial complex that manufactures concrete piles to an apartment complex, condominiums, and residential homes within 25 feet of the bayou. The project was placed on the original National Priorities List in 1983 and included consideration of second degree burns being received by Coast Guard divers during bayou sampling.

Creosote operations began in 1892 and continued until 1970 when a fire destroyed the plant. Remedial Investigations (RIs) and Feasibility Studies were completed in 1987, and a Record of Decision (ROD) was signed in March 1987. The results of these investigations indicated concentrations of up to 12% polynuclear aromatic hydrocarbons (PNAs) in surface waste piles, several percent PNAs concentrations in the bayou sediments, and pure product creosote within the ground water. The remedial action ultimately selected included the following:

a) onsite incineration of 46,500 cubic yards of contaminated sediments and 5,000 cubic yards of waste pile materials;
b) placement of an engineered cap over the ash from the incinerator and the residual surface soils greater than 100 ppm total PNAs;
c) pump/treatment/reinjection of contaminated ground water; and
d) the estimated total construction cost was $55 million.

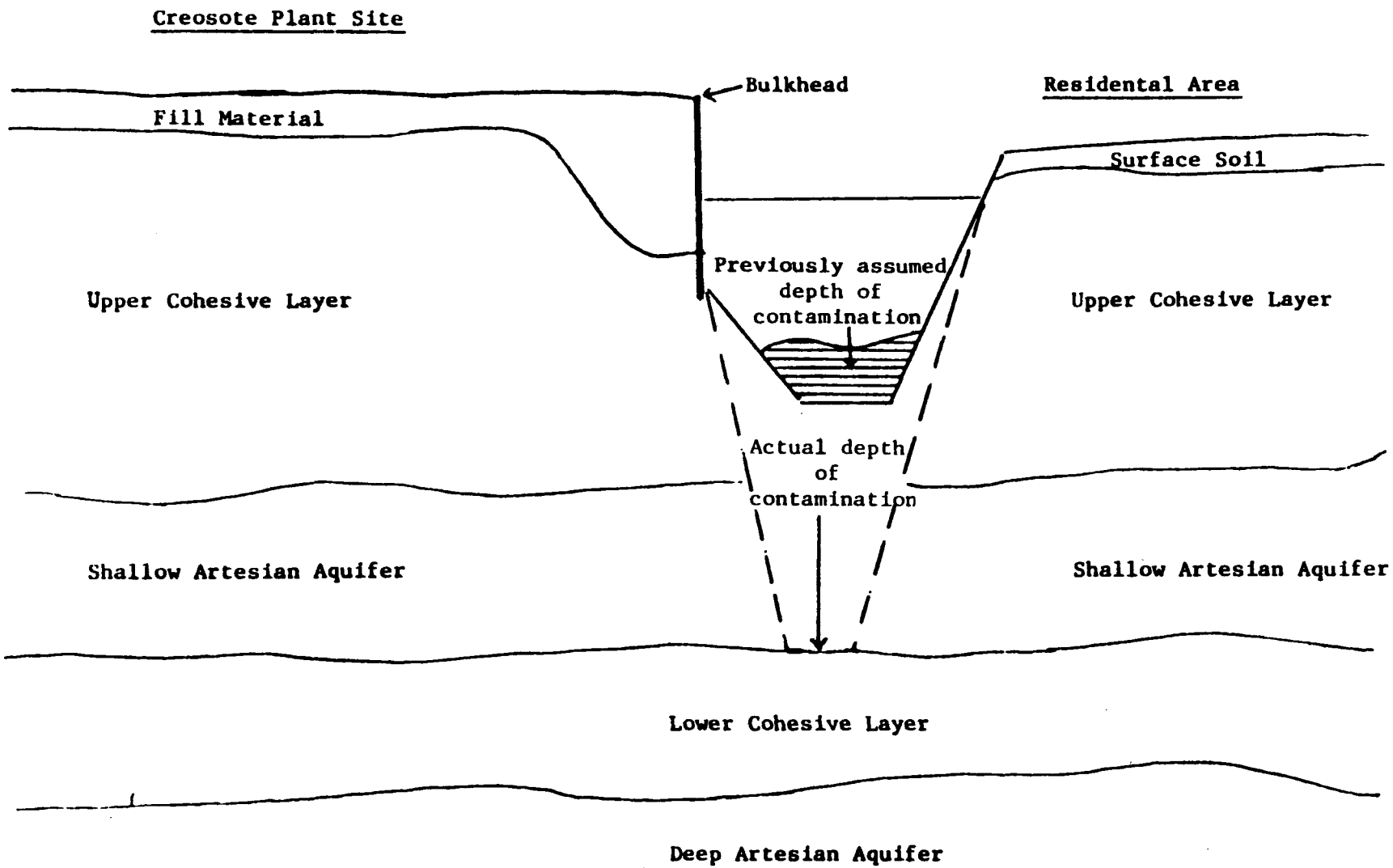
The RI characterized the general subsurface (Figure 1) at the abandoned facility as being a few feet of sandy fill material (surficial aquifer), overlaying about 20 feet of clay, which covered approximately 12 feet of silty sand (shallow artesian aquifer). Below the silty sand is another clay layer 10 to 20 feet thick which rests on top of a sand layer (deep artesian aquifer). The surficial aquifer results from recent rainfall events and does not yield significant quantities of water; but it has been shown to contain dissolved PNAs whenever water is able to be recovered. The shallow artesian aquifer is known to contain free product creosote, while the deep aquifer is uncontaminated.

The Agency in conjunction with the State of Louisiana indicated to the local community, during the ROD public meeting, that the selected remedy was "conceptual" in nature and that additional studies were necessary during the Remedial Design (RD) phase. These studies were to be conducted to gain more refined information so as to develop detailed plans and specifications.

In 1988 RD field investigations were started to support the preparation of detailed plans and specifications. This work was conducted by CH2M HILL under contract to EPA with the Army Corps of Engineers providing technical assistance. The primary emphasis of this phase was to: 1) further delineate boundaries of contaminated ground water and to evaluate the ability to pump and treat; 2) better determine the extent of contaminated sediments and related engineering properties; 3) evaluate the air emissions during dredging and materials handling; and 4) evaluate the ability to dewater the sediments. As a result of these investigations the project was divided into two operable units as detailed below.

GENERAL CROSS-SECTION

(not to scale)



BAYOU BONFOUCA

Figure 1

III) GROUND WATER OPERABLE UNIT

The delineation of the ground water contaminant plume and the pilot treatment operations were conducted in the summer and winter of 1988. A total of 38 permanent and temporary wells were installed on the plant site and along the edge of the bayou. As a result of this work, free product creosote was discovered in three discreet plumes rather than one continuous one as presented in the ROD. Figure 2 reveals the approximate shape of these plumes. This figure also shows that two of the plumes are on the plant property while the other is adjacent to the bayou and appears to be influenced by contamination within bayou sediments. A cross section of where this aquifer is located is illustrated in Figure 1. The free product is located in about a 12 foot zone at a depth of approximately 20 feet below the surface. The creosote tends to be in separate seams throughout the aquifer rather than in one layer at the bottom of the formation.

A ground water pilot study was conducted to evaluate the capabilities to extract and treat these contaminants. Two different types of extraction well configurations were evaluated. A separate phase extraction system as shown in Figure 3 was used to assess the ability to extract the creosote oil separately from the water in the aquifer. This system consisted of oil extraction wells in an equilateral triangle with wells at 2.5 foot spacings, and a water extraction well within the center of the triangle. The principle behind this array was to create a hydraulic gradient in the water recovery well which would also induce the flow of pure product creosote toward the oil recovery wells. The other system consists of a conventional multi-phase pump system as shown in Figure 4. This type of system removes both oil and water from the formation at once rather than trying to extract them as different phase liquids. It was found that the creosote could best be removed through multi-phase pumps instead of separate pumps for oil and water phases. This study also revealed that reinjection of the treated water, as anticipated in the ROD, was not viable because of the physical properties of the aquifer. The aquifer does not readily allow the reinjection of water and as such it was believed this would potentially be a costly ineffective action.

A second aspect of this pilot study was an evaluation of the most effective form of treatment of the extracted groundwater prior to discharge. The RD pilot study showed that the most effective treatment train was oil-water separation; followed by sand, oleophilic and carbon filtration; and then aeration before discharge to the bayou. This system proved to be effective in meeting the discharge criteria of the State of Louisiana and the National Pollutant Discharge Elimination System.

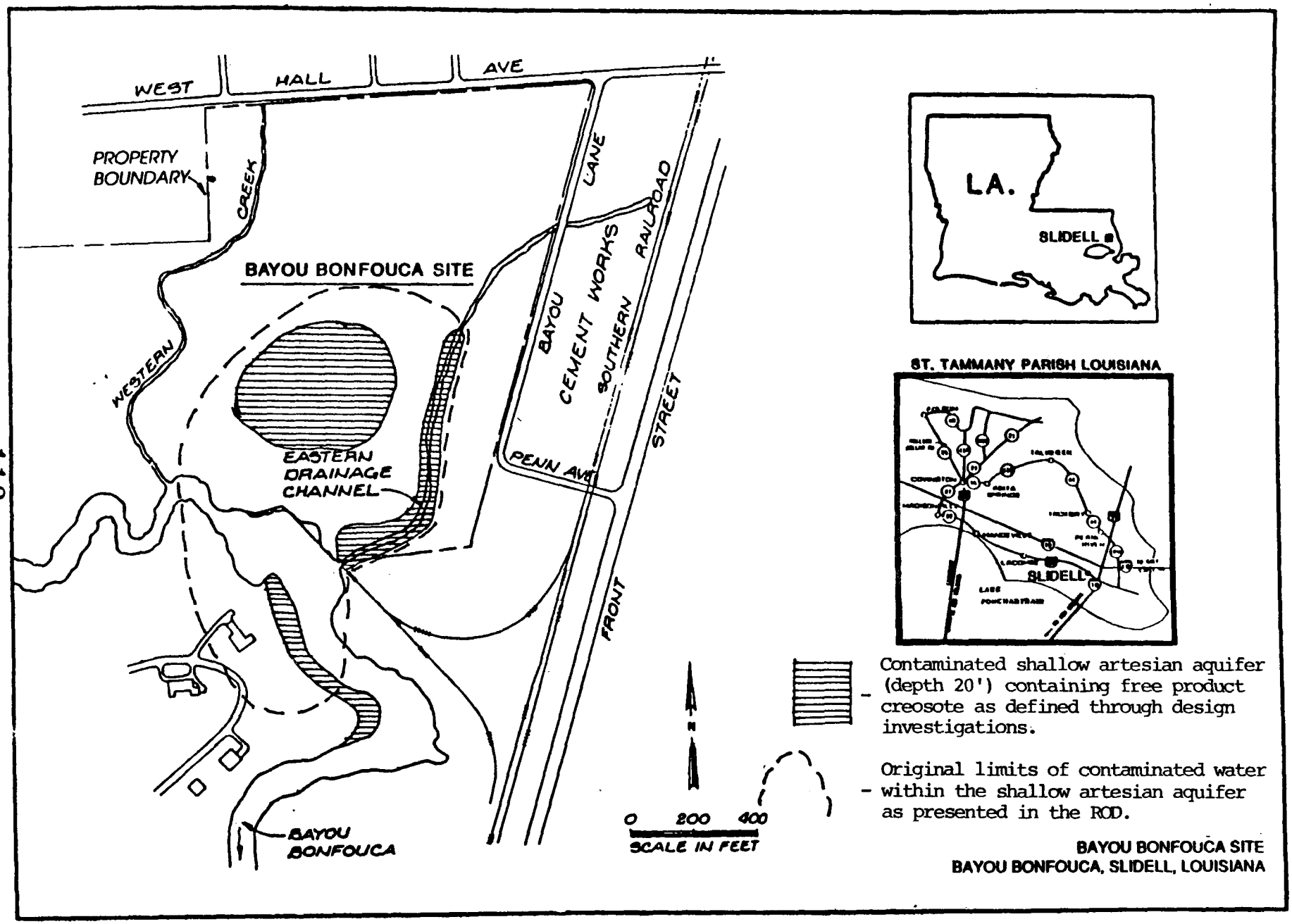

WEST HALL AVE
PROPERTY BOUNDARY
CREEK
WESTERN
BAYOU BONFOUCA SITE
EASTERN DRAINAGE CHANNEL
BAYOU BONFOUCA
BAYOU CEMENT WORKS
SOUTHERN RAILROAD
LANE
PENN AVE
FRONT STREET
0 200 400
SCALE IN FEET
LA.
SLIDELL
ST. TAMMANY PARISH LOUISIANA
SLIDELL
Contaminated shallow artesian aquifer (depth 20') containing free product creosote as defined through design investigations.
Original limits of contaminated water within the shallow artesian aquifer as presented in the ROD.
BAYOU BONFOUCA SITE
BAYOU BONFOUCA, SLIDELL, LOUISIANA

Figure 2

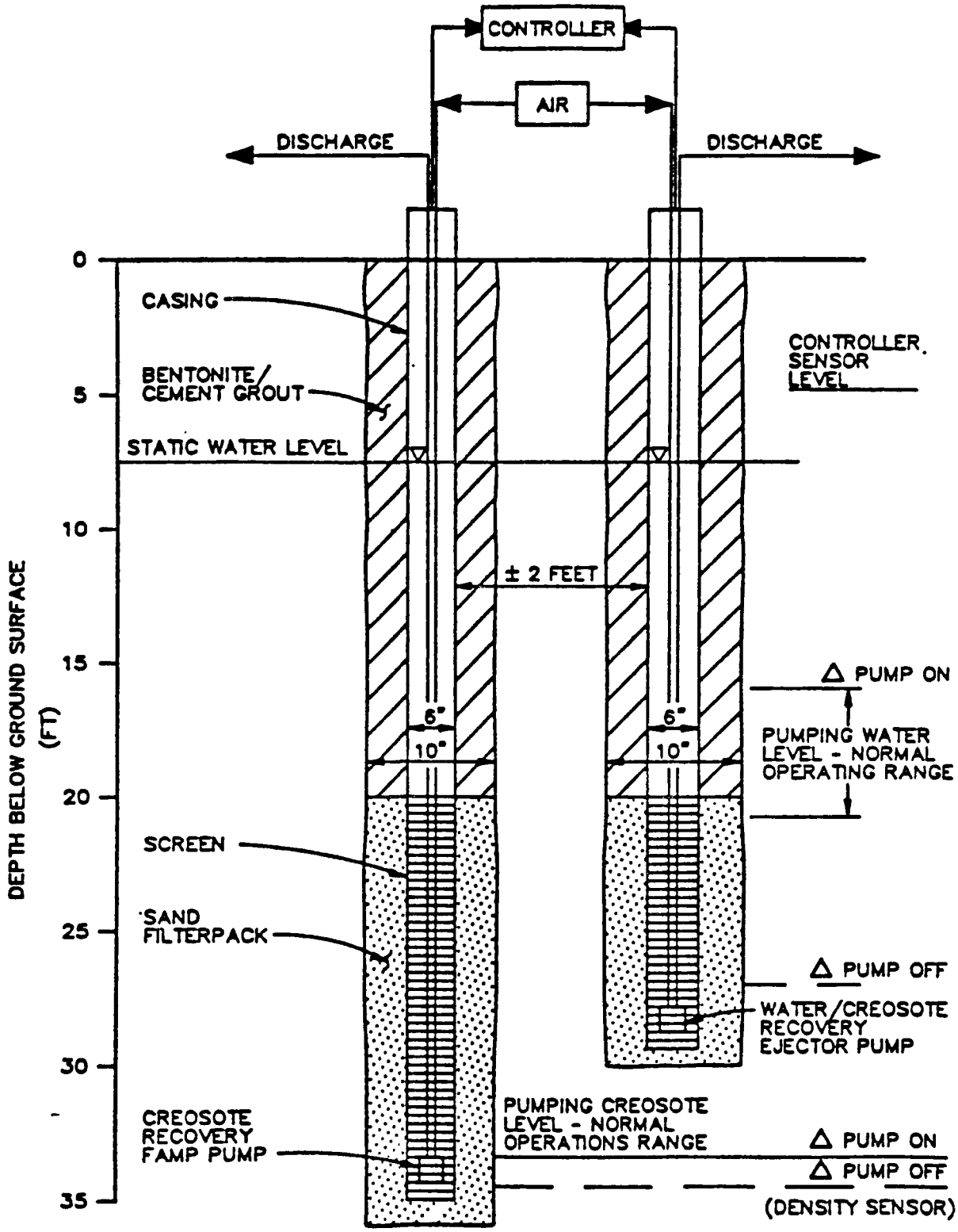


Figure 3
GENERALIZED SCHEMATIC FOR SEPARATE PHASE EXTRACTION WELL SYSTEM (SYSTEM "A")
Bayou Bonfouca
Slidell, Louisiana

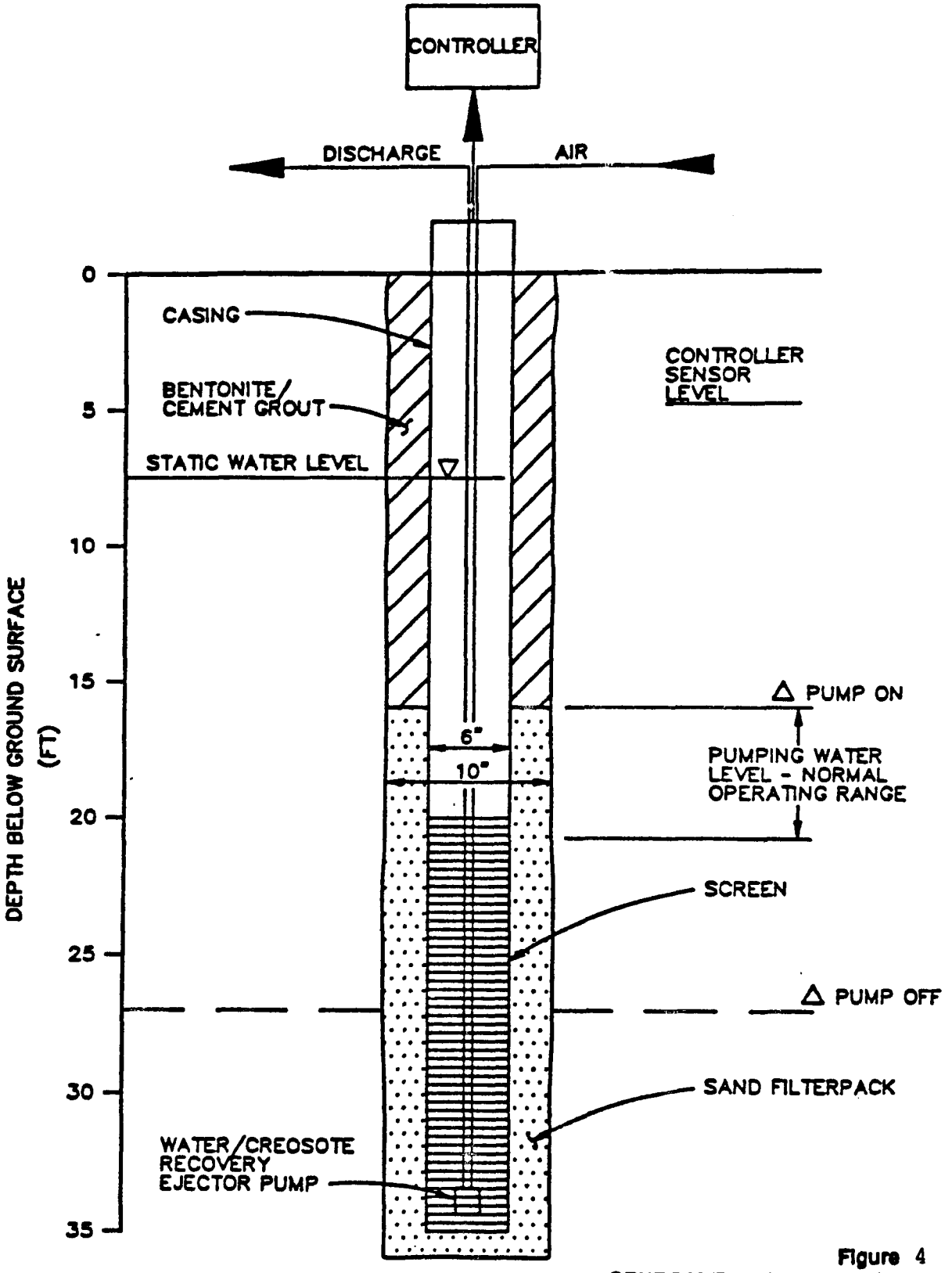


Figure 4
GENERALIZED SCHEMATIC FOR TOTAL FLUIDS EXTRACTION WELL SYSTEM (SYSTEM "B")
Bayou Bonfouca
Slidell, Louisiana

CONCLUSIONS

This pilot study proved quite useful in developing detailed plans and specifications for full scale operations. During the course of this pilot study, EPA and the State of Louisiana decided that the site cleanup could be expedited by separating the ground water out as an operable unit. This action was taken so that work could be conducted on this phase while further evaluation was made on the sediments as detailed below. The Ground Water Operable unit RA contract was awarded in October 1989 to Chemical Waste Management for $4.7 million and is currently under construction with planned startup of the treatment plant in June 1991. Thirty-nine extraction wells have been installed at the site and the plant is designed for a maximum flow rate of 50 gallons per minute with an operational flow rate of approximately 20 gallons per minute.

IV) SOURCE CONTROL OPERABLE UNIT

A) SEDIMENT INVESTIGATIONS/EXPLANATION OF SIGNIFICANT DIFFERENCES

During the sediment investigations it was discovered that the horizontal and vertical extent of contamination were greater than assumed from previous investigations. A total of 55 borings were made in the bayou to evaluate the physical properties of the sediments and to establish cutlines for dredging.

The bayou borings near the creosote plant revealed that the upper cohesive (clay) layer, as shown in Figure 1, was not continuous across the bayou as previous studies had indicated. The reasons for this error lie in the incorrect interpretation of previous boring logs and sub-bottom geophysical profiles. In addition, previous sampling was limited in depth because of concerns with penetrating the presumed upper clay layer, thereby possibly further spreading contamination. Due to the non-continuity of this upper clay layer, creosote was found at a maximum depth of about 17 feet below the mudline, rather than at 5 feet as previously assumed. These borings also showed that the horizontal extent of contamination was approximately 4,000 feet, almost twice that presented in the ROD. As a result of these investigations it was determined the volume of contaminated sediments was approximately 170,000 cubic yards, rather than the 46,500 cubic yards presented in the ROD. An example of one of the cross-sections within the bayou is shown in Figure 5. This figure provides PNA concentrations for grab and composite samples, and the classification of the sediments according to the unified soil classification system.

This volume increase caused the selected remedy to be re-evaluated and the work associated with this phase of the project was identified as the Source Control Operable Unit. Camp Dresser & McKee (CDM) was contracted by EPA to re-evaluate the alternatives presented in the ROD and consider the applicability of any new

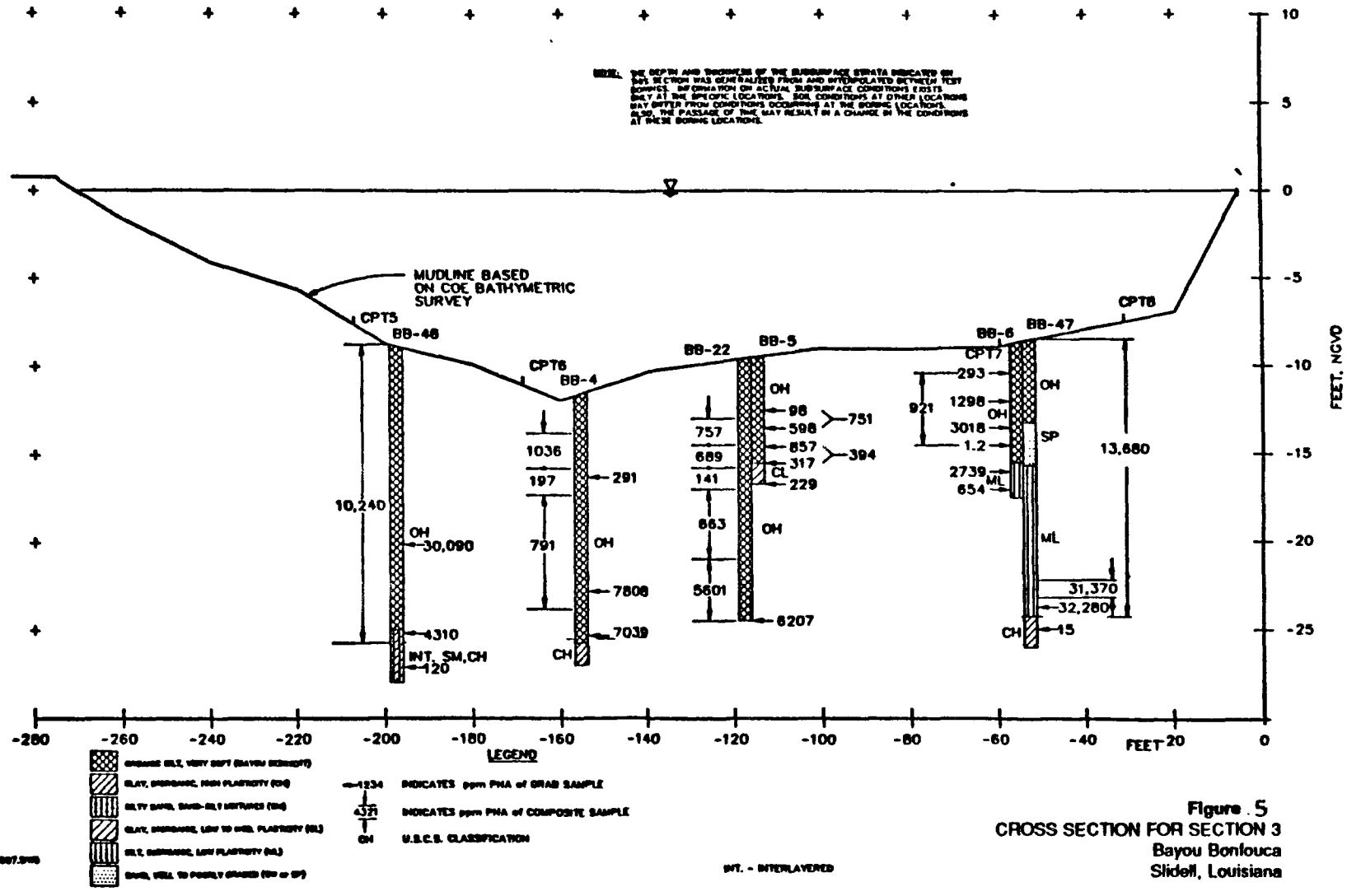


Figure 5
CROSS SECTION FOR SECTION 3
Bayou Bonfouca
Slidell, Louisiana

innovations since the ROD was signed. The conclusions of these studies showed that the selection of on-site incineration was still the most appropriate method to remediate this site. Other methods such as inplace solidification, partial sediment removal, or on-site placement within a RCRA vault were found not to adequately address the goals of EPA or the State of Louisiana to reduce the toxicity or mobility of the contaminants. The study indicated that bioremediation (in a slurry reactor) might be effective in reducing the concentration of contamination, however, further review showed that it would most likely not achieve the same percentage reduction as incineration. In addition, it was found that the cost of bioremediation would be slightly more than incineration. This was due in part to the fact that the final material would have to be dewatered prior to landfilling.

The CDM study did recommend two areas for consideration during incineration which were further evaluated in the RD; using a centrifuge during dewatering and utilizing waste heat from the incinerator for additional drying of the sediments. Since EPA decided a request for proposal (RFP) would be used for the RA contract, both these options could be considered by the perspective bidders. This study proved valuable by confirming that the correct remedy was chosen in light of the significant change in volume. As a result of this activity and other considerations, EPA and the State of Louisiana issued the first Explanation of Significant Differences within EPA, Region 6. The community was in agreement with this proposal and this document serves as an amendment to the ROD rather than requiring further delays associated with submitting a new ROD.

It was decided early in RD process that the most appropriate means to address these sediments was through use of predetermined cutlines. Given such a complicated project, specific cutlines are anticipated to provide a much more controlled cleanup resulting in a significantly reduced contractual risk to the State and EPA. The cleanup standard was established as 1300 ppm PNAs based on waste mobility and on a risk assessment assuming children wading in the bayou and the cleanup goals previously established by EPA. Consideration was also given to environmental concerns in that the bayou currently has no biota in the sediments because of elevated concentrations of PNAs. Therefore, plans were made to backfill the bayou offering a clean environment for the restoration of biota and a barrier against direct contact with any residual contamination in the sediments.

An additional concern with bayou restoration is with shore stabilization. The bayou, in the area of concern, abuts either residential, commercial properties or wetlands. These considerations serve to highlight the need to progress thoroughly and with discretion. During the dredging operations sheetpiles or similar slope support are necessary to protect the bayou bank and associated wetlands.

CONCLUSIONS

EPA was faced with a difficult situation when the volume of contaminated materials more than tripled that presented in the ROD. This dilemma was addressed by conducting a thorough evaluation of possible alternatives and close coordination with the State and community, allowing the project to continue without major delays. The issuance of an Explanation of Significant Differences document rather than reopening the ROD also saved significant time which potentially could have required an additional two year delay. This situation also emphasizes the need for adequate investigations during the RI stage of any site.

B) AIR PILOT STUDY

Pilot studies were also conducted during the Remedial Design of the Source Control Operable Unit to simulate actual air emissions during construction. This action was necessary because previous data indicated that the potential existed for large nuisance and possibly toxic emissions. The pilot activities consisted of dredging 12 cubic yards of sediments, separation of different size materials on a vibrating screen and conducting 23 air test runs. (Air monitoring took place at the point of operation and at specified distances downwind). The air emissions tests were conducted in test chambers as shown in Figure 6 and included agitation and raked capabilities. Agitation was through a variable speed mixer to simulate dilute and pumpable material, while the raked chambers allowed disturbance of higher solid materials which is reflective of stockpiled sediments. The results indicated possible emissions of benzene, naphthalene, toluene, ethyl benzene, and trimethyl benzene. Volatilization of these compounds was modeled using the Industrial Source Complex Short Term Dispersion model and showed no significant releases, however, it did indicate the benefits of a properly detailed air emissions control strategy. The results of these studies was presented in the RD package to allow bidders to estimate air emissions. This data, and associated transport modelling, was also used to select compounds for establishing fenceline and dredge air action limits (contractor control levels) for protecting off-site residents. The final specification for these air emissions was as follows:

Monitoring at the Dredge

Monitoring Period	Compound	Action Limit (mg/m3)
5-min reading	Benzene	9
	Ethyl Benzene	1635
	Naphthalene	225
	Toluene	1680
	Trimethyl Benzene	1125

Monitoring on the Bayou Banks

Monitoring Period	Compound	Action Limit (mg/m3)
15-min average	Benzene	3
	Ethyl Benzene	545
	Naphthalene	75
	Toluene	560
	Trimethyl Benzene	375
1-hour average	Benzene	3
	Ethyl Benzene	435
	Naphthalene	50
	Toluene	375
	Trimethyl Benzene	125
28-day and annual averages (annual averages are cumulative)	Benzene	0.008
	Ethyl Benzene	0.4
	Naphthalene	0.14
	Toluene	2.0
	Trimethyl Benzene	0.050

The Air Action Levels are based on an analysis and consideration of EPA's Health risk numbers and OSHA standards. A case in point is that the 1 hr. average at the Bayou Bank for Benzene is 3 mg/m^3. If this limit is reached the contractor would be required to institute emission mitigation controls. This number also corresponds to OSHA's numerical standard for the TLV. It is important to note that the EPA criteria are far more protective of human health than the OSHA standard even though similar concentrations are employed. An important difference is that EPA's action level kicks in after 1 hr. as opposed to being an acceptable concentration for an 8 hour period, 5 days a week for forty years.

These levels were also established at the fenceline of the facility where the incinerator will be located. However, the fenceline limits also include action criteria for particulates which will result from ash handling. The basis for these action levels is a consideration of short and long term health data and that specifications emphasize contractor controls.

CONCLUSIONS

The benefits of this air emissions pilot study were greatly realized during the development of this design package and the cost for it was more than adequately justified through reducing unknowns to the bidders. The emissions criteria developed for this contract also shows a logical approach to handling this important issue in which many Superfund sites are just now beginning to realize the potential effect.

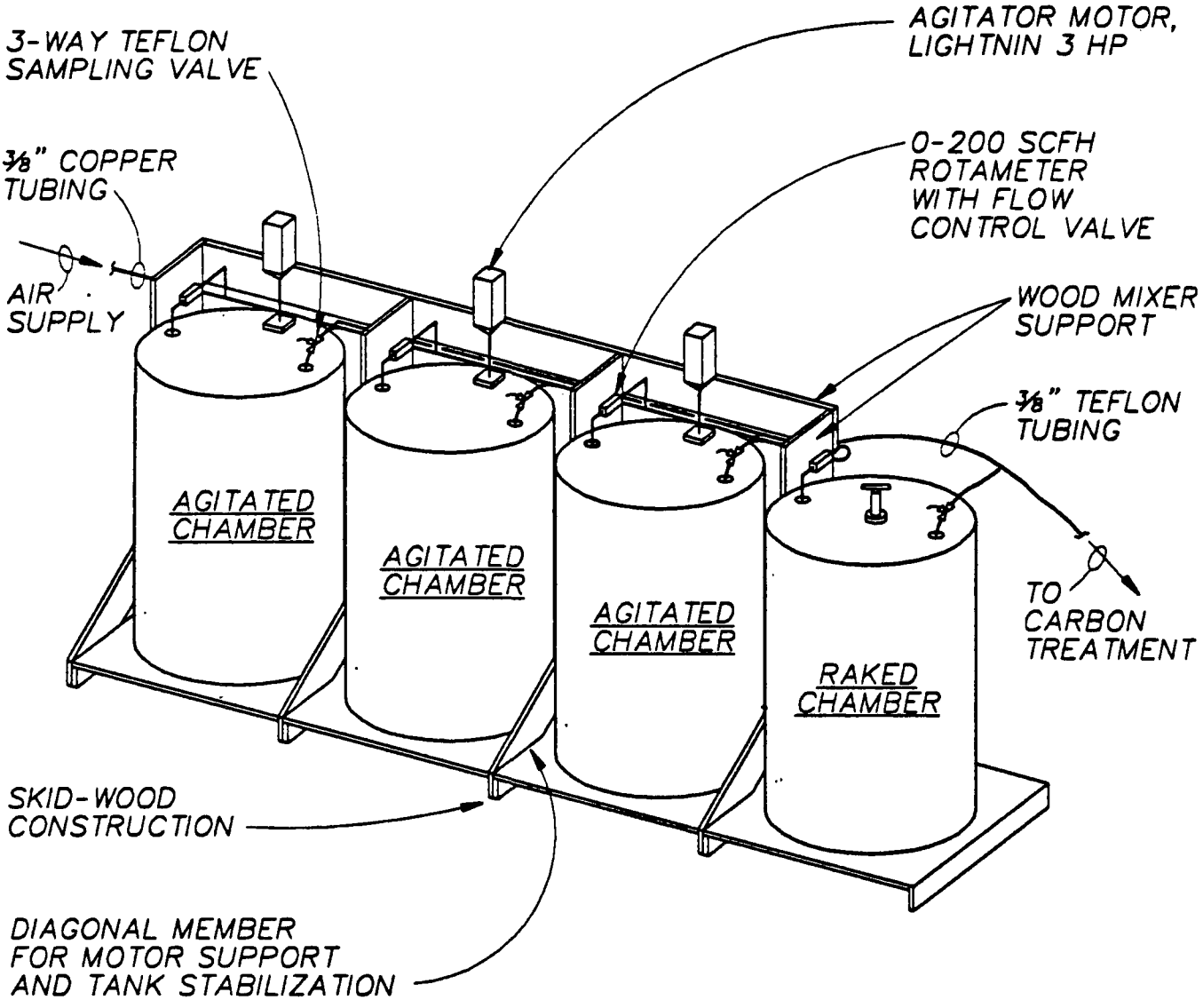


Figure 6
SCHEMATIC OF AIR TEST CHAMBERS
Bayou Bonfouca
Slidell, Louisiana

NTS

C) DEWATERING PILOT STUDY/PAYMENT FOR INCINERATION

At the same time as the Air Pilot Study a dewatering study was also conducted. Dewatering activities during these pilot studies included polymer testing, vacuum assisted drying beds, gravity settling, filter press, centrifuges, and belt filter presses. Figure 7 presents a table of the results of these tests which was provided to the bidders as part of the RD package. This data indicates that when additional moisture is added to the sediments it can be difficult to remove it prior to incineration. It also shows that the moisture content of the incinerator feed would be greatly affected by the dredging and dewatering process train rather than the insitu moisture content of the sediments.

This data indicated that the most reasonable contractual approach for handling the dredging, incineration and dewatering aspects of this project was through paying for the ash on a dry weight basis as it leaves the incinerator. This is completely different than the typical incineration contract where measurement is based on the wet material entering the incinerator. This approach places the responsibility on the contractor to optimize his process train to reduce the amount of water in the feed material to the incinerator. Although several bidders disagreed with this approach, they were unable to provide a more suitable method to handle this situation. Associated with this issue was the realization that to pay for the ash material on a dry weight basis the contract documents would require a flexible performance strategy. Therefore, EPA and the State of Louisiana decided to use a performance based specification rather than a detailed design approach that specified specific treatment trains (i.e., centrifuge followed by infrared incineration, filter press followed by rotary kiln, etc.). The contract was advertised for construction as a request for proposal (performance based) rather than an invitation for bids (detailed design).

CONCLUSIONS

In consideration of these studies and a detailed review of the different possible process trains, it was decided that the most effective way to advertise this RA was through a request for proposals (RFP). It was recognized, that given such a complex project, there could be a number of different approaches. EPA's intent was to encourage competition, innovation and cost savings for the Government. The RD for this construction was completed in September 1990 and award of the RFP is expected in May 1991. The issue of paying for incineration was addressed through weighing the material as it exits the incinerator rather than weighing the feed material. This assures the Government that the contractor optimizes the process train to ensure that unnecessary moisture is minimized.

Comparison of Dewatering Results from Design Investigation, Field Study, and Offsite Laboratory Activities

	Ranges of Solids Contents Achieved by Various Dewatering Methods for Each Investigation		
	Design Investigation	Field Study	Offsite Laboratory
Polymer Jar Test	17.2-22.0	NP	NP
Batch Flux Curve Test	(4.6-10) 14.7-22.6	NP	NP
Gravity Settling Test	(4.6-10.7) 16.7-19.3	(4.7-15.2) 14.4-26.2	
Buchner Funnel Test (Vacuum Filtration)	(14.2-22.6) 46.4-53.2	NP	(26.5) 37-39
Filter Leaf Test	43-47%	(5-20) 33.2-42.7	NP
Sludge Drainage Test (Preliminary Thickening Test)	(17.5) 42.3-50.7	(16.9) 31.0-49.2	(10-30) 23-30
Belt Filter Pressure Test	*	NP	NP
Bench-Scale Vacuum-Assisted Dewatering Test	NP	(18-22) 37.1-42.5	NP
Pilot Scale Plate and Frame Filter Press Test	NP	(8.2-22) 22.6-30.0	NP
Vacuum-Assisted Sludge Dewatering Bed Testing	NP	(8-22) 22-38	NP
Basket Centrifugation Test	NP	NP	a.(43.1) b.46.7-50.4
Solid Bow Centrifugation Test	NP	NP	(25.0-36.5 40.0-47.8
Continuous Solid Bowl Centrifuge Test	NP	NP	(35.0) 25.2-51.2
Pressure Filtration	NP	NP	(36.5) 45-46
Trommel Screen Dewatering Simulation Test	NP	NP	(30.0) 32.6

Upper entry ( ) indicates the initial solids concentrations.
Lower entry indicates the final dewatered sludge solids concentrations.
All concentrations presented as percent total solids by weight.
NP = Test not performed.
*Test did not produce reportable results.

Figure 7

D) Value Engineering

A Value Engineering (VE) study was prepared by the Corps' Kansas City District during the preparation of plans and specifications. As previously noted, the RA contract was an RFP rather than a detailed design. This approach allows the bidders more flexibility in implementing the selected remedy and at the same time allows a more competitive bid by not specifying a certain type of incinerator or dewatering train.

Although, the Corps' study generated some very good suggestions, some of which were included in preparing the specifications, the cost effectiveness of a VE study for an RFP remains questionable. A VE study is more appropriate when you have detailed plans, wherein you have specific process trains and are able to optimize the approach. In an RFP it is expected that the bidders will include VE considerations in putting together their proposal and as such it may not be as effective for the Government to do this during the design. Furthermore, it remains questionable in an RFP if bidders should be allowed to present a VE proposal as currently allowed in some contract clauses. The very nature of an RFP should be that the contractor has selected the most cost effective approach; therefore, allowing the contractor to gain additional monies from use of a VE contract clause is unreasonable. If a bidder knew in advance that only one or two proposals were expected, then the proposal might not be optimized knowing that if the contract was won then additional funds could be made through a VE.

E) FUNDING

Because of the high cost of this project, in excess of $100 million, the EPA was concerned about RA funding for the Bayou Bonfouca Source Control Operable Unit. This money is to be provided by the State of Louisiana and EPA, which pay 10 percent and 90 percent, respectively. Typically on Fund lead projects, for which the Corps administers the contract, the Agency is responsible for providing, up front, 100 percent of these funds through an Interagency Agreement (IAG) prior to advertisement. Funding for this work was proving to be a big issue since this was a significant portion of the overall yearly RA budget for Superfund projects. Because of this, Region 6 approached the Corps during the initiation of the RD to reduce the funding impact by conducting the work in two phases or to see if the Corps could use their continuing contracting authority. Continuing contract authority allows the Government to fund multi-year contracts on a yearly basis; i.e., not providing all the monies up front.

It was subsequently discovered that the Army Corps of Engineers has not been granted continuing contract authority on Superfund construction contracts although it has been for Civil works. After attempts failed in trying to get the Corps to obtain such authority for this project, EPA decided that the contract should be divided into two phases based on site activities as discussed below. The first phase was classified as the base portion, and the second was the option phase.

The base consists of mobilization of the incinerator and water treatment facilities, preparation of plans (i.e. Health and Safety, Air Monitoring and Action Plan, etc.), preparation of the initial landfill, the incinerator trial burn and incineration of approximately 15 percent of the material. The reason for the selection of these items was that EPA wanted to ensure adequate funding was available for all work related to preparing the landfill, and the incineration of the waste piles. This also allowed a logical break point between work on the contamination at the abandoned plant and those activities with bayou sediments.

The option phase includes mobilization of the dredge equipment, stabilization of the bayou slopes (i.e. sheetpiles, etc.), dredging and backfilling of the bayou, incineration of the contaminated sediments, construction of the landfill cap, demobilization of the incinerator and other related facilities and one year of post closure operation and maintenance.

CONCLUSIONS

Phased funding for dividing large scale projects is recommended whenever the contract is anticipated to take several years and funds are not readily available. This approach allows EPA to address several sites at one time rather than tying funds up on only one large project. However, it is also highly recommended that the Corps pursue the authority to advertise these large Superfund projects under continuing contract authority.

F) BONDING

Bonding remains one of the most important issues related to advertising large (> $20 million) Superfund RA projects in this country. The size of the Bayou Bonfouca contract concerned EPA, Region 6, in that without proper consideration to bonding it was felt this item could severely restrict competition. Previous experience within the Region, coupled with discussions with the sureties industry, had indicated that bonding was hard to obtain on projects larger than $20 million. The primary reason for this dealt with liability concerns. Above this value, the number of bidders able to obtain bonding is reduced and, therefore, competition is severely limited. This issue was brought to the attention of the Army Corps of Engineers especially in light of

their conventional approaches in requiring performance bonds of 100 percent of the contract amount or advertising projects entirely as a service contract. In a service contract the contractor is not required to submit any performance bonds and the Government is at significant risk if the contractor defaults. Alternately, in 100 percent bonding the Government is fully protected and as is the case on large scale projects, the Government may be overly protected.

EPA approached the Corps' Kansas City District and requested a reduced bonding that would both protect the Government and allow competition. Region 6 decided not to arbitrarily use the $20 million value which most sureties would provide, but to actually estimate the cost to the Government to readvertise and mobilize a new contractor if the existing contractor defaulted. This process involved a thorough review of the bid items and an evaluation of the potential impacts (contractual and environmental) if the contractor defaulted at different points during the anticipated schedule. Through this effort the final total performance bonding requirements developed by the Corps were completed and they are as detailed below.

(1) If the bidder provides a total performance bond for both the base and option contracts, the total amount shall not exceed 12 percent of the total cost.
(2) The bidder could choose to provide an initial bond for the base contract only, and then increase it at time of award of the option contract. If this alternative was selected the requirements are for 20 percent bonding on the base and then additional bonding of up to 12 percent of the total cost at award of the option.
(3) It was also required if the contractor decided to separate bonding by alternative 2 above that the same surety or sureties were utilized. This requirement aides in ensuring that the Government does not accept the risk of improper sureties after the base is awarded.

IV) SUMMARY

This paper has presented a wide spectrum of issues that were addressed during the development of the Remedial Design for the Bayou Bonfouca Superfund site. In particular, it covers the issues of pilot studies, payment for incineration on an ash weight basis, Value Engineering, funding and bonding on large scale projects. It also provides brief discussions on other key design issues that may be relevant for scoping future work on other similar Superfund sites.

Pilot studies have shown to be helpful in developing plans and specifications, in addition to ensuring cleanup goals can be achieved. This site has also shown that it's very important to address these issues during the RI stage rather than during the RD. If these studies were conducted prior to the ROD, the actual volume of contamination would have been discovered greatly simplifying the overall process.

This project has presented an innovative approach for paying incineration quantities. Rather than utilizing the weight of the feed material, EPA choose to pay on the dry weight basis of the ash. This protects the Government against the payment for incinerating unnecessary moisture and places the responsibility on the contractor to optimize the process train. This approach should be considered on future Superfund sites.

It was found that Value Engineering studies related to projects that are scheduled for procurement as a Request For Proposals may not be as effective as they are with Invitations For Bids. In fact the nature of RFPs is such that a Value Engineering process should be conducted by the perspective bidders during the preparation of their proposal and not after award of the contract. If a contractor does not optimize his approach through use of VE principles he risks not winning the contract.

Up front bonding on large scale projects (>$20 million) is often difficult to obtain, especially when the costs are expected to be around $100 million. By dividing the work into 2 separate phases, the EPA was able to prioritize Agency-wide remedial needs of available dollars for numerous other sites. As a related point, it is suggested that both EPA and the Army Corps of Engineers pursue the authority for awarding continuing contracts.

Performance bonding has been found to be a critical item related to the ability to obtain competitive bids and to protect the Government against contractor default. Although service contracts have been used, since there is no bonding required in this type of contract, the EPA could be left with at least the cost for procuring a new contract if the existing contractor fails to perform adequately. The possibility exists that additional costs exist due to uncompleted work such as environmental releases, etc. At the same time it is unreasonable to automatically require 100 percent bonding without a consideration of the actual costs associated with default and reprocurement. On the Bayou Bonfouca site it was found that approximately 12 percent of the total construction amount would be sufficient as a performance bond. This type of approach is recommended for other large remedial projects.

V) REFERENCES

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Soil Remediation in the New Jersey Pinelands

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INTRODUCTION

The Lang Property Superfund Site located in the environmentally sensitive New Jersey Pinelands was a former cranberry and blueberry farm where 1,200 to 1,500 drums of hazardous waste were indiscriminently stored. The hazardous waste in the drums included a variety of volatile organic as well as some inorganic contaminants. In December 1978 the State of New Jersey ordered that these drums be removed. The drums were removed, but somehow their contents were emptied on-site, resulting in the contamination of the sandy surface soil and underlying Cohansey Aquifer. The site was listed on the National Priority List (NPL) in December 1982, and a remedial investigation/feasibility study (RI/FS) was initiated in May 1985. A record of decision was issued in September 1986 and by November 28, 1988, the remedial design (RD) was completed and the soil was remediated. Completion of the RI/FS, RD and the remedial action (RA) was ahead of schedule and within budget.

Several items contributed to the successful completion of this remediation in a relatively short time frame. These included: 1) the use of the results of the RI/FS to separate the soil and groundwater contamination into two separate operable units; 2) the use of the geophysical investigation and subsequent test pits to identify potential excavation problems; 3) the cooperation among the U.S. Environmental Protection Agency Region II, (EPA) the U.S. Army Corps of Engineers (COE), the New Jersey Department of Environmental Protection, (NJDEP) and the consultants; and 4) the dedication of the team to completing the remediation prior to enactment of certain Land Ban provisions. This deadline was imposed since the Record of Decision (ROD) did not call for pretreatment of the soils prior to disposal at an approved landfill. One of the highlights of the remedial design was a three day meeting with the representatives from the COE, EPA and the consultants who had conducted both the RI/FS and the RD for soil remediation. Questions that were raised by the approving and implementing agencies were satisfactorily and quickly answered by the RD consultant. Additionally, consultation was available from the RI/FS team regarding details of the site conditions. Another time saving item was the elimination of the 60% design submittal from the usual submittals of 30%, 60%, 90% and 100% complete. The

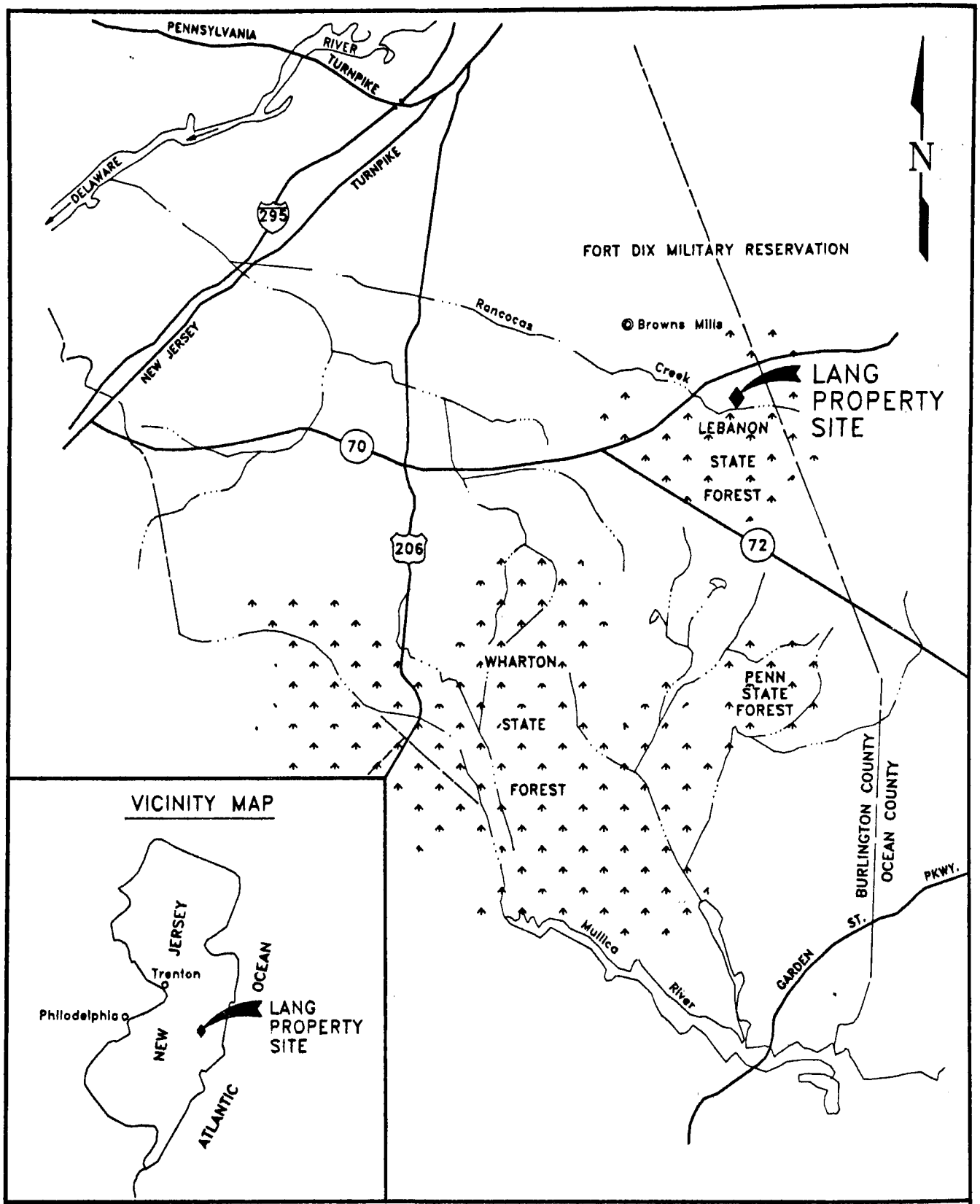
purpose of this paper is to present a case study emphasizing that collection of the information during the RI/FS phase needed to complete the RD not only accelerated the RD schedule but also resulted in substantial savings. It will also compare the cost estimates from the FS, the RD, and that of the selected contractor. This paper will also address the benefits of contractor continuity, a key element of EPA's 10-year Alternative Remedial Contracting Strategy (ARCS).

BACKGROUND

The Lang Property is a 40-acre area in a rural portion of Pemberton Township, Burlington County, New Jersey (see Figure 1). Cranberries and blueberries were once cultivated on most of the property, however, at the time of the RD, only a few small blueberry fields were active. In 1975, 1,200 to 1,500 drums of unidentified chemical waste were discovered in a four acre clearing on the property. The State of New Jersey filed a suit against the Langs and an order was issued by the Superior Court of New Jersey directing the Langs to remove the waste from their property. The Langs subsequently hired a local contractor to remove the waste. This contractor removed the drums from the site, however, prior to their removal, the drums were apparently punctured and the chemical waste was spilled onto the ground.

Several factors related to the site area combine to magnify the severity of the problem at Lang Property. First, the site is located within the Pineland National Reserve, a large and unique forest expanse located within the highly populated Northeast United States. This area has been recognized as an important and environmentally sensitive natural resource. The site and adjacent areas, including the down gradient wetlands, are part of the Pinelands Preservation Area District and are regulated through the New Jersey Pinelands Protection Act which has been adopted by the Pinelands Commission. Second, the site overlies the Cohansey Sand Formation, a largely undeveloped aquifer under water table conditions which has tremendous potential for future water supply development. Third, groundwater is typically present from one to three feet below ground surface and recharge to the groundwater occurs rapidly by infiltration through the coarse sandy soil. Consequently, chemical contamination spilled onto the ground surface at the site would have easy access to the groundwater. Finally, the nature of the soil and groundwater in the site area tend to make the contamination problem more severe. Sandy soils typical of the Pinelands, particularly the coarse sands found near the ground surface, tend to be relatively inert with very little organic matter. Such soils have little capacity for adsorption of organic contaminants from the groundwater. In addition, the groundwater itself tends to have a low chemical buffering capacity. Consequently, contamination in the groundwater in this area has very little potential for adsorption by soil particles or chemical neutralization by natural constituents of the groundwater.

CC Johnson & Malhotra, P.C. (CCJM) has been actively involved in a variety of work assignments at this Superfund site. As a member of the Zone 1 REM/FIT Contract under prime contractor NUS Corporation, CCJM completed the Remedial Action Master Plan (RAMP) in 1983. In 1984 CCJM began work on the Remedial Investigation/Feasibility Study (RI/FS) under a subcontract to Camp Dresser & McKee Federal Programs Corporation as a team member of the REM II Contract. Under this contract CCJM was responsible for all aspects of the RI/FS even though parts of the project were conducted by other team firms. CCJM provided the Site Manager, the primary contact between the REM II Team and EPA, and coordinated all subcontractors including those on the team and those in the subpool (drillers, laboratory, test pit excavators, and treatability study laboratories). A ROD was signed in 1986 for both groundwater and soils. CCJM was also responsible for conducting the Remedial Design (RD) and participating in the Remedial Construction Management (CM) for the soils portion of the selected remedy. The RD and CM were conducted as part of the REM III Contract under which Ebasco Services Inc. was the prime contractor. Again, CCJM was given the primary responsibility for conducting the site management aspects of the work assignment including interaction with EPA and COE. Through three different contracts, CCJM was able to maintain



SCALE NONE	LOCATION OF LANG PROPERTY SITE	FIGURE 1
DATE APRIL 1991		

C.C. JOHNSON & MALHOTRA, P.C.

contractor continuity and provide EPA with a series of documents that successfully allowed them to remediate contaminated soils at the site and to determine the proper course of action for the groundwater remediation.

Remedial Action Master Plan

The first document prepared after the site was listed on the NPL was the Remedial Action Master Plan (RAMP), which included a data and records search from the file materials at EPA and NJDEP. Based on this information, an assessment of the site was made. The results of the site assessment included a recommendation that a full RI/FS be conducted. Within the RAMP, a preliminary scope of work, schedule and cost estimate to complete the RI/FS were also made.

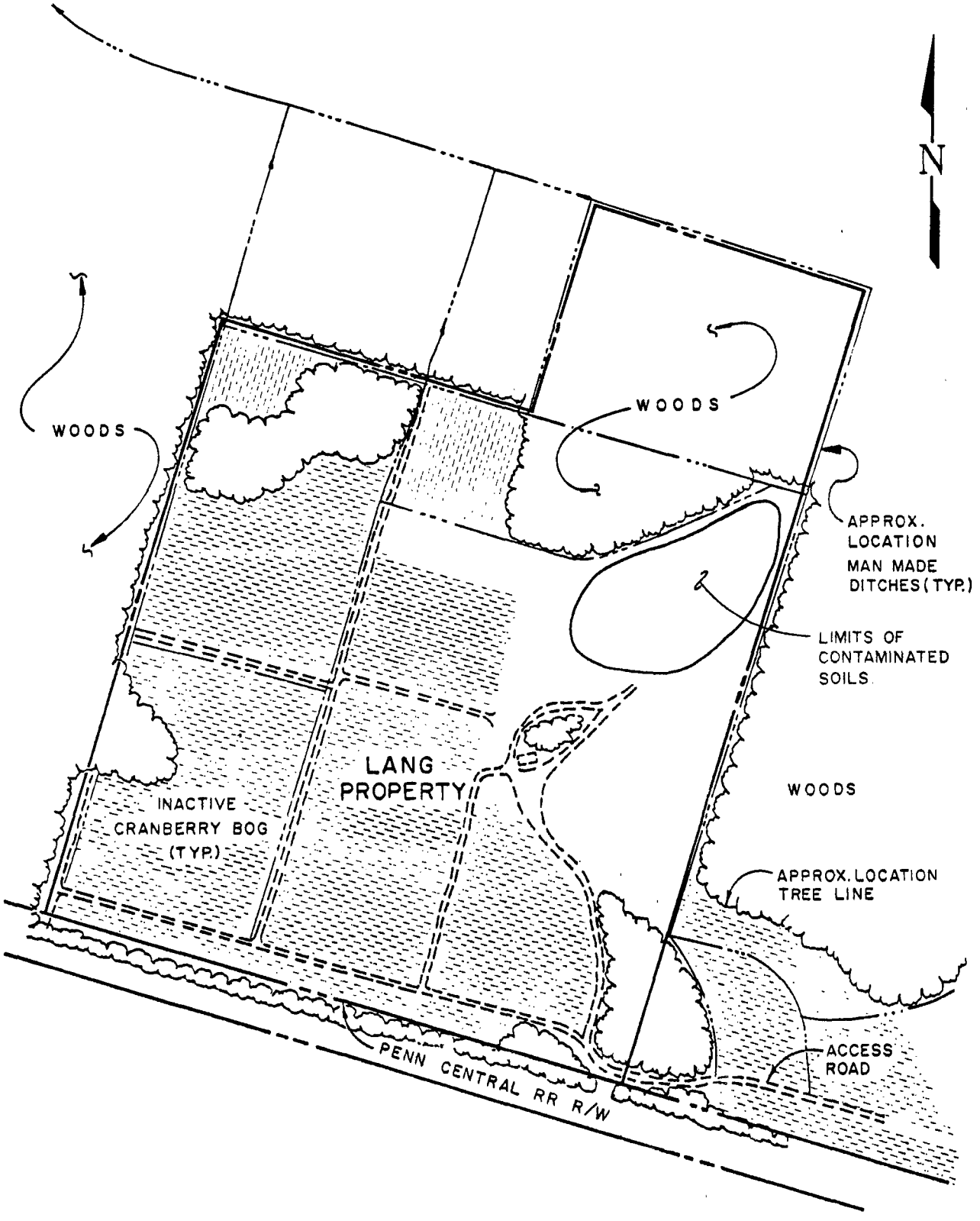
Remedial Investigation

The scope of the RI/FS was determined after detailed discussions with EPA. The purpose of the RI was identified as determining the nature and extent of contamination. An approach which used screening techniques (such as geophysics and head space analysis of soil samples) was followed. The screening techniques were followed by more detailed soil sampling at the surface and at various depths as part of the boring, well drilling and groundwater sampling activities. After a scoping meeting with EPA and NJDEP, a Work Plan was prepared which detailed the scope of the RI and FS as well as estimated the total cost and the schedule to complete the RI/FS.

As a result of the work done during the RAMP, it was determined that the source of contamination at the site was the shallow soils and groundwater. Since all of the drums were removed from the area, no other source existed. Based on file data, the nature of the contamination included, at a minimum, volatile organics as well as heavy metals. The first phase of the RI, therefore, focused on soils and shallow groundwater in the cleared area at the end of the access road. A site map showing various features is shown in Figure 2. The RI included the following investigations:

- Site Survey
- Geophysical Survey
- Test Pit Excavation
- Soil Screening
- Soil Sampling
- Surface Water and Sediment Sampling
- Wellpoint Installation and Sampling
- Monitoring Well Installation and Sampling
- Vegetative Investigation
- Air Monitoring

Several conclusions were made using the RI data regarding chemical contamination at the Lang Property. Surficial soils in a two-acre portion of the four acre clearing where disposal took place were contaminated with volatile organic compounds and metals. Low levels of PCBs were also present in the surficial soil in at least two locations. Vertical contamination of soils in portions of the site known to contain chemical pollutants was limited to a maximum depth of 20 feet. Surface water and sediment samples collected from areas of ponded water within the on-site disposal area were also contaminated with volatile organics as were samples collected from a location along the ditch draining the site. This location is in position to receive surface water draining from the on-site disposal area (see Figure 2). It is believed that this ditch may have intercepted contaminated shallow groundwater as it traveled from the on-site disposal area. Shallow groundwater beneath the on-site disposal area is contaminated by volatile organic compounds and metals. Although this contaminated



SCALE 1" = 270'	LANG PROPERTY SITE	FIGURE 2
DATE APRIL 1991		

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groundwater plume could have limited concentric migration, its migration is principally in a northwesterly direction.

This first phase RI answered most of the questions necessary to prepare a Feasibility Study, although there were still some unanswered questions. For example, locations for the northwestern most point of groundwater contamination and the northern most point of soils contamination could not be established. Since most of the questions were answered, it was decided that instead of going through an entire second phase of an RI, the FS should be completed and the remaining sampling would be completed as part of the RD. This decision by EPA allowed the ROD to be signed in a much more timely fashion.

Based on the results of the RI, the contaminated groundwater had not migrated far from the area of disposal. This was attributed to the very slow ground water flow rate resulting from the minor northwest gradient. The ditch which drains the site may have acted to intercept some of the shallow groundwater from which volatilization of contaminants may have occurred. Groundwater below a depth of 30 feet showed no evidence of contamination. This is because soil permeability in the site area decreases with depth below ground surface. In addition, the groundwater exhibits slight upward and downward vertical gradients that vary with the season. In the long term, this resulted in no net downward movement of contaminated groundwater through the subsurface zone detected during the RI.

An RI Report was prepared describing the results of the field investigations. The report presented the data collected and evaluated the results with respect to applicable or relevant and appropriate requirements (ARAR's). ARARs included state and federal criteria along with those from the Pinelands Commission.

A risk Assessment was conducted which identified chemicals of concern, exposure pathways and populations at risk.

Feasibility Study

A Feasibility Study (FS) was conducted for the site which screened technology types, developed alternatives and provided a detailed evaluation of remedial alternatives in order to assist EPA in selection of the Remedial Action which was included in the ROD. Alternatives considered included excavation and either off-site disposal or incineration of contaminated soils. Groundwater alternatives included pumping and either disposal in a local wastewater treatment facility (after pretreatment), on-site treatment with disposal by injecting the treated groundwater into the aquifer from which it came, or off-site treatment and disposal. All alternatives were evaluated in terms of costs, reliability, implementation, safety, public health and welfare, environmental impacts, regulatory requirements, and community acceptance. CCJM also provided support to EPA during preparation of the ROD.

Record of Decision

As described in the ROD, the selected remedy includes the following:

- Enclosure of the disposal area by a perimeter fence.

- Excavation of contaminated on-site soils to a depth of two feet (totaling approximately 6,500 cubic yards), removal of these soils to an approved off-site landfill disposal facility, and backfilling the excavated area with clean fill. (Note that the actual quantity of soils was closer to 8,000 cubic yards.)

- Extraction of approximately 30 million gallons of groundwater, with treatment and on-site injection.

- Removal of on-site debris (tires, abandoned vehicles) and vegetation to facilitate filling and grading the site in the future.

- Post-construction operation and maintenance to verify the effectiveness of this remedy.

The disposal of contaminated soils by landfilling was chosen instead of incineration due to the excessive costs associated with incineration. Surficial soil samples (0-2 feet deep) were analyzed for hazardous substances, and total volatile organic (TVO) concentrations were plotted on the site map for each sample location. Limits of excavation were established by defining the area of soil contamination greater than 1 mg/kg TVO concentration as required by NJDEP clean up criteria.

DISCUSSION

Remedial Design Description

As a subcontractor to Ebasco Services, Inc. under the REM III contract, CCJM was given full responsibility for conducting the Remedial Design for the soils remedy at the Lang Property Site. Under this REM III work assignment, CCJM prepared construction drawings and specifications, following COE guidelines. The drawings and specifications were completed under a tight schedule and included construction of road improvements, a contractor support area, a contamination reduction area, and removal and hauling of approximately 8,000 cubic yards of contaminated soil to an approved off-site disposal area. Provisions were made to dewater any soils that contained too much water for off-site disposal. CCJM interacted effectively with EPA, COE, NJDEP, and Ebasco to complete this project in a timely and cost effective manner.

The ROD addressed both the groundwater and the soils contamination at the site; however, it was decided by EPA that the two contaminated media would be handled through two separate operable units. This was done since additional data collection for the groundwater was more extensive than that required for the soils. Additionally, by separating the two media, remediation of the soils could proceed much quicker, thereby reducing the source of contamination. Also, there was no technical basis to wait for the groundwater cleanup to be accomplished prior to cleaning up the soils. Since the ROD did not include provisions for pretreatment of the contaminated soil prior to off-site disposal at an approved hazardous waste landfill, the soil clean up had to be implemented prior to the 1988 Land Ban restrictions which would have required such treatment.

Use of RI/FS Data in Remedial Design

The RI/FS had determined that the type of contamination in the top two feet of soil at the site included compounds which had not leached out by rain into the subsurface soils. These compounds were generally not very soluble in water and had high carbon partition coefficients (indicative of immobile compounds). This was the main finding of the RI/FS that aided in the selection of the remedy which required excavation of the top two feet and flushing of all contaminated soils deeper than two feet as part of the groundwater remedial action. This information was very important and was used during the RD to determine the depth of excavation of most of the contaminated areas of the site.

In other areas of the site, the question of excavating buried drums created some concern during the design. The geophysical survey results indicated that there were drum-like signatures in certain areas

of the site. This information necessitated greater caution during the design of the excavation and during the excavation itself. Since this information was available, test pits were excavated (using Level B Personnel Protective Equipment) to determine the presence of buried drums prior to completion of the design. The test pits revealed that hundreds of buried tire rims, car seats and other metal objects were present, but no drums. The results of the geophysical survey were used to identify the location of the buried metal objects and were used in the drawings and specifications for the excavation in these areas.

Cost estimates in FS were used to determine the relative costs among the alternatives. Cost estimates completed during the RD were more refined and were used to determine as close as possible the actual costs from the contractors who would bid on the contract. Cost estimates, for the selected remedy estimated as part of the FS and the RD are compared to the bid from the selected contractor below:

FS Estimate	RD Estimate	Selected Contractor Bid
$1,739,240	$4,125,450	$3,606,550

Problems Encountered

During design, there were several problems that were anticipated for this project including, control of high concentrations of volatile emissions during construction; soil excavation in areas of shallow ground water; adequate dewatering of the contaminated soil for transportation and disposal; and disposal of decontamination water.

The concern for exposure to high concentrations of volatile organics resulted from the experiences on site during soil sampling and drilling activities. During any intrusive activities, chemical odors were prominent and photoionization detector readings were elevated. Several options were considered for designing a system to alleviate this concern. One option included using spray foam to cover excavated areas until new fill material could be brought in to cover the area. Another option considered was to direct the contractor, through the specifications, to excavate and backfill simultaneously or in such a manner that open areas were not left exposed for extended periods of time. Requiring the use of personnel protective equipment to protect the workers and monitoring down wind was also considered. The final specifications alerted the contractor to the potential emissions problem but did not specify a method (other than monitoring) for dealing with it. The contractor was to monitor and, if required, take appropriate measures to minimize these effects. During construction, monitoring was conducted which indicated that the problem was not as serious as anticipated. The contractor was able to complete the majority of the excavation first and backfill later which helped keep the project on schedule. Personnel protective equipment was used on an as-needed basis.

Excavation in an area where the groundwater is only two to three feet below the ground surface presented two concerns. One concern was for the type of equipment necessary to perform the excavation without getting stuck. The other concern was that the soil had to pass the Paint filter test prior to hauling and acceptance at the approved landfill. Again, no specific requirements were made in the specifications for the type of equipment to be used and the contractor was able to supply drag lines as well as conventional earth moving equipment (pans, front end loaders, backhoes, etc.). Based on the description of the site provided, the contractor was able to complete the work satisfactorily. The drawings and specifications required a dewatering pad for soil that did not pass the Paint filter test due to high moisture content. Due to the time of year that the excavation occurred and the

method employed by the contractor during the excavation, the dewatering pad was not needed very frequently.

Disposal of contaminated water from dewatered soils or from decontamination of equipment was another concern. On-site disposal of the drainage from dewatered soils would have been the easiest but was not allowed by the regulatory agencies. Therefore, provisions for collecting this water along with the decontamination water, storing it on site and then hauling it off site for final treatment and disposal were made in the specifications. There were no major problems encountered during the construction. The contractor, however, built a different type of dewatering pad at no additional cost to the project which performed adequately, especially considering that very little dewatering was necessary. All contaminated water was collected and hauled off site as required in the specifications. Another change to the design made by the contractor, at no additional cost to the client, included constructing a weigh station on site instead of using a "nearby" existing station to determine the quantity of soil hauled off site. This made the work much more efficient and more manageable.

One of the largest components of the RD work assignment was the design of the access road. Due to the remote location of the site, the access road, although not directly part of the hazardous waste handling, provided an essential link in the successful completion of the project. The existing road was a four mile long rural road constructed of sand and pea gravel. The remedial design required that the road be improved to allow heavy truck traffic to pass. Geotechnical samples were collected and analyzed in order to determine the necessary improvements including the amount and size of gravel required. One problem with the access road that occurred during construction was that the quantity of gravel used significantly exceeded that estimated. However, the problem was not serious enough to impact the schedule.

Schedule Boosters

The RD and subsequent construction followed an ambitious schedule. Several items contributed to maintaining this schedule. Close coordination among the many parties involved was an important part of the success of the project. The EPA Regional Project Manager was at the center of the communications network. Communications were maintained almost daily among EPA, COE, NJDEP, Ebasco Services Inc., and C.C. Johnson & Malhotra, P.C. This close contact kept all parties knowledgeable about their specific roles and allowed problems to be solved as soon as they were identified.

An additional help to the schedule was simultaneous distribution of the draft documents to all individuals within the review agencies who were responsible for providing comments. This process avoided double mailings and lost time. EPA made this project a high priority so that the soils remedy called for in the ROD could be implemented prior to enactment of the Land Ban restrictions which would have required that the soil be treated prior to off- site disposal. If the schedule were not followed, the ROD would have to be revisited, and the RD would have to be redone. It was in the government's best interest economically to complete the project on time. The COE in Kansas City understood this and joined in with NJDEP to dedicate the necessary resources to the project in order to provide expedited reviews. This dedication to the project was key in completing the project on schedule.

Another boost to the schedule was provided by conducting all field work under the existing REM II contract. Approved field operations plans and health and safety plans were in place which avoided generation of new plans under the REM III contract. This saved time and money. Coordination between the two contracts was made easy since the lead firm, CCJM was maintained throughout the project. Contractor continuity is an important aspect of Superfund projects. Knowledge of the site and easy access to background documents as well as knowing the local contacts provides a much more

efficient method of operating these long term RI/FS/RD/RA projects. This is one reason that EPA has established the ARCS contracts. These contracts are set up for 10 year periods and allow contractor continuity without the administrative details of issuing new contracts for each phase of the project.

An efficient method of incorporating agency comments on the RD occurred during a three-day meeting held at the COE's offices in Kansas City. At this meeting representatives from the various divisions within the COE, EPA, Ebasco, and CCJM were present to discuss the specifics of the RD. When questions came up about why the design was done in a specific manner, the people who knew the answers were present to respond. Regulatory decisions were made at the meeting and after the meeting was completed, there was a clear understanding about the direction that the project was moving. Everyone present knew how their comments would be incorporated. This meeting provided an effective means to resolve conflicting comments. It also provided the reviewers with a better understanding of the project and made subsequent reviews easier and quicker.

The last item which had a beneficial effect on the schedule was omitting the 60% design submittal from the usual submittals of 30%, 60%, 90% and 100%. For this specific project this omission was appropriate since the close coordination that was necessary in order to meet the schedule resulted in the reviewing agencies being very familiar with the project drawings and specifications. By omitting this review, many days were saved that would have been required to prepare, to review, and to revise the 60% submittal. The final product did not suffer from lack of this submittal.

The result of completing this project in such a timely fashion was a savings of costs budgeted for the soils RD. Actual costs of the work assignment were approximately 75% of those budgeted. Maintaining the schedule was a primary factor in these savings.

CONCLUSIONS

Several items contributed to the successful completion of the design and implementation of the selected remedy in a relatively short time frame. These included: 1) the use of the results of the RI/FS to separate the soil and groundwater contamination into two separate operable units; 2) the use of the geophysical investigation and subsequent test pits to identify potential excavation problems; 3) the cooperation among EPA, COE, NJDEP and the consultants; and 4) the dedication of the team to completing the remediation prior to enactment of certain Land Ban provisions since the ROD did not provide for treatment of the soils prior to disposal in an approved landfill. One of the highlights of the remedial design was a three day meeting with representatives from COE, EPA, Ebasco and CCJM. CCJM conducted the RI/FS for the entire site and the RD for soil remediation. Questions that were raised by the approving and implementing agencies were answered by the design engineer immediately. Additionally, consultation regarding the details of the site conditions were made with the individual that was responsible for the RI/FS. Another time saving item was omitting the 60% design submittal from the usual submittals of 30%, 60%, 90% and 100% complete. The success of this project is a tribute to the team work and dedication of the individuals and the agencies involved.

When Is a Superfund Remedial Action "Complete"? A Case Study of the Crystal City Airport RA Implementation and Transition to O&M

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INTRODUCTION

The Crystal City Airport, Crystal City, Texas, located 120 miles south of San Antonio was listed on the National Priorities List (NPL) in 1986. The Record of Decision (ROD) for the first and only operable unit was signed in September of 1987 and selected onsite consolidation under a RCRA cap as the Agency's remedy. Primary contaminants included toxaphene, arsenic and DDT. Construction activities began on February 5, 1990 and were completed on September 25, 1990. This project has been a state-lead site funded by federal Superfund monies through the Texas Water Commission (TWC). Community and Congressional interest has been high throughout the Superfund process at this site.

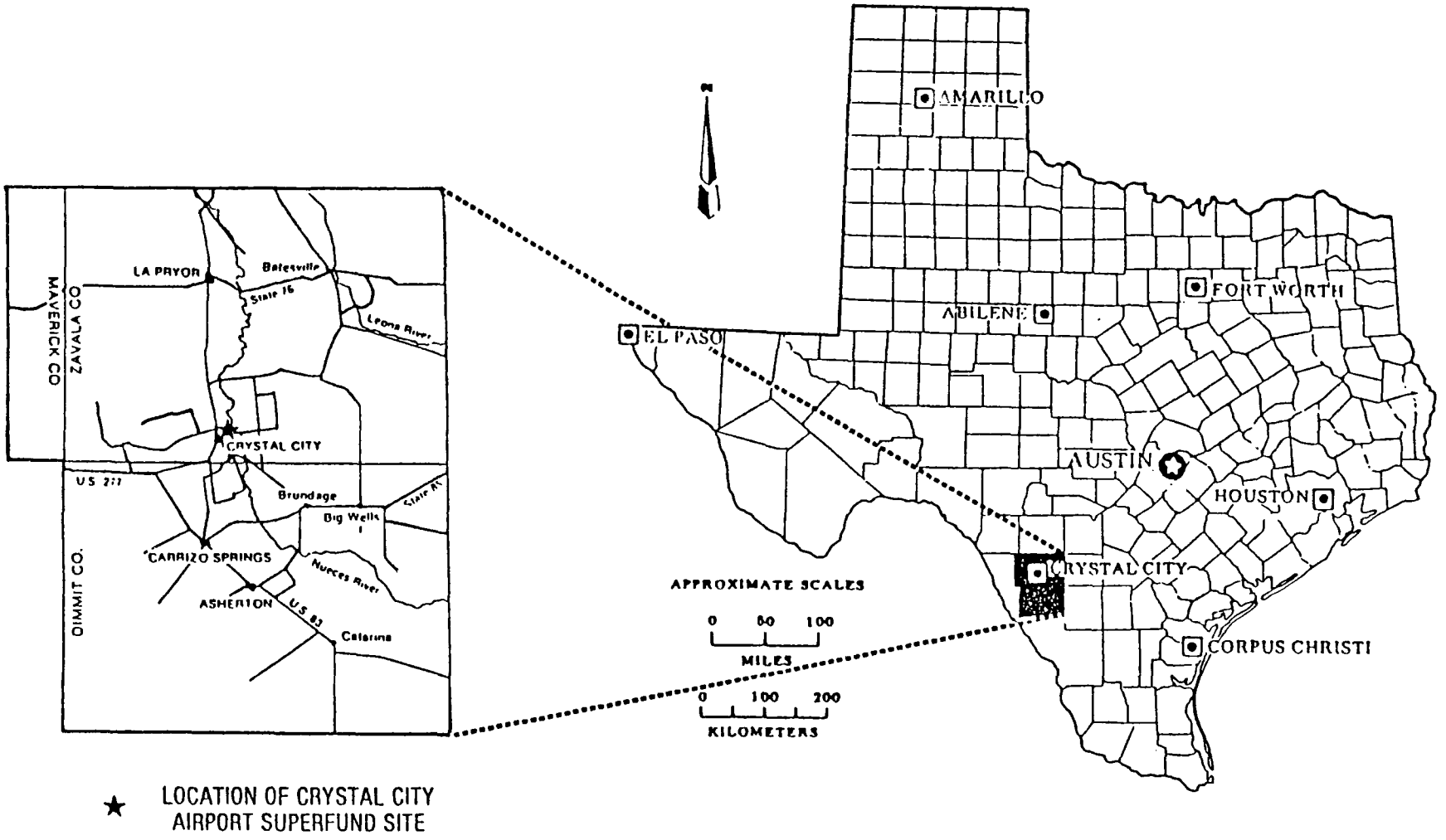
Although the project was not technically complex, an unsupportive local community made the implementation of the Remedial Action (RA) at this site particularly challenging. A brief overview of the site's remedial history developed from the draft Closeout Report will be presented as background information. A description of how the state of Texas and the region are implementing the post-construction transition period into the Operations and Maintenance (O&M) phase will be discussed relative to Superfund Comprehensive Accomplishments Plan (SCAP) milestones.

There are varying degrees of RA "completion" that will differ on a site specific basis. The current agency trend is toward defining these degrees in an increasingly rigorous manner with revised SCAP items such as "RA Award" and "O&F" (Operational and Functional) now being tracked. As more sites move toward the RA phase, uniform Agency-wide interpretation of these definitions will be necessary. The RA and post-RA SCAP definitions will be discussed and compared with the actual dates realized at Crystal City.

BACKGROUND

The Crystal City Airport Superfund site is located within the city limits of Crystal City, Zavala County, Texas, in the South-Central portion of Texas commonly referred to as the Winter Garden District as depicted in Figure 1. The area is a region of low population where the economy is dominated by agriculture and oil and gas production. Crystal City is the county seat of Zavala County with approximately 8,000 residents from a total county population of 11,500. The nearest large population center is San Antonio, located roughly 100 miles northeast[1].

The Crystal City Airport is owned by the City of Crystal City. The site covers an area of approximately 120 acres. Airport related facilities include a 3550-foot asphalt runway, a rotating beacon on an elevated tower, a windsock, paved taxiways, and several buildings and foundations. The land surrounding the airport property has a variety of uses. A closed municipal landfill, also owned by the City of Crystal City, is located directly adjacent to the airport to the northeast. To the north,



EBASCO EBASCO SERVICES INCORPORATED	MAP OF WINTER GARDEN DISTRICT AND LOCATION OF CRYSTAL CITY AIRPORT SUPERFUND SITE	FIGURE NO. 1

the land is used as pasture land. Directly west of the site is a private residential area and a public housing project. Southwest of the site is an elementary school, a high school, and associated athletic fields. South of the site is a second residential area. Southeast of the site is more agricultural grazing land[1].

During World War II, the airport site was owned and operated by the U.S. military. It was used primarily for housing persons detained during the war. In 1949, the U.S. Government deeded the property to the city. The City of Crystal City has operated the facility as a municipal airport since that time. Under lease arrangements with the City, several private companies operated aerial pesticide applicating businesses at the Crystal City Airport beginning in the early 1950's. By 1982, all aerial applicators were bankrupt and pesticide application operations were discontinued at the airport. Upon declaring bankruptcy, the former operators abandoned various equipment and numerous deteriorated drums on site[1].

Remedial Planning Activities. A complete timetable of the Crystal City Superfund site can be found as Attachment A to this report. The Texas Department of Water Resources (TDWR), the predecessor agency to the TWC, initiated a preliminary site investigation on April 25, 1983 at the request of local officials acting on behalf of concerned citizens. On June 13 and 23, 1983, additional reconnaissance investigations were conducted to characterize the type and extent of the contamination. At least 50 drums of various agricultural pesticides and herbicides were observed, as well as extensive soil staining apparently indicative of historically poor handling practices. Samples of the drinking water and air did not contain any detectable contamination. An Immediate Removal Action was initiated by the EPA on October 31, 1983, to remove the most highly contaminated materials. During this action, approximately 40 cubic yards of waste and between 50-70 drums of material were placed in two temporary disposal cells onsite, mixed with lime and capped with clay[2]. The temporary cell locations were documented for the future permanent remedial action. The removal actions taken were consistent with the permanent remedy.

After followup investigations on December 15, 1983, February 14, 1984, and March 29, 1984 by the TWDR, EPA, and the Texas Air Control Board (TACB), an additional removal action was determined to be warranted to further reduce short-term risks posed by the site. In May, 1984, an additional 19 drums were transported offsite to a permitted treatment, storage and disposal facility for disposal. A fence with a locked gate was constructed around the site to limit public access, and warning signs were posted[2].

A Hazard Ranking System (HRS) package for the Crystal City Airport was finalized in June of 1984. The overall site score was 32.26. The HRS package identified direct contact and air inhalation as the exposure routes of primary concern, with HRS route scores of 50.0 and 43.0 respectively. The toxicity and concentrations of the compounds at the site in addition to the close proximity of target receptors were noted in the HRS[3]. The Crystal City Airport was proposed for inclusion during the second update of the NPL on October 5, 1984. NPL listing was finalized on May 20, 1986[4].

The TWC and the EPA entered into a Cooperative Agreement on September 28, 1985 for a state-lead Remedial Investigation and Feasibility Study (RI/FS). In June of 1986, the TWC contracted Ebasco Services Incorporated to perform the RI/FS. Phase I of the RI fieldwork lasted from September through October, 1986, and Phase II fieldwork was conducted during January and February of 1987. Ebasco submitted a draft RI report for EPA and TWC review in April of 1987. A draft FS followed in May, 1987. The RI and FS reports were finalized in June and July of 1987 respectively.

Extent of Contamination. The RI results indicated the contamination on-site consisted of numerous organochlorine pesticides and herbicides, arsenic, and minor amounts of other semi-volatiles. DDT, toxaphene, endrin, and dieldrin were chosen as indicator chemicals for each class of organochlorine

compounds, arsenic for inorganics, and benzo(a)pyrene for the semi-volatiles and acid/base neutrals. Because concentrations of DDT, toxaphene, and arsenic predominated throughout the airport, these compounds were chosen as action level indicators[1].

The two fieldwork phases of the Remedial Investigation included 314 surface and subsurface soil samples. Off site samples of surface water and sediments were obtained from seven stream stations. Forty five separate soil borings were drilled including a dry 180 foot hydrogeologic test hole. Air sampling at both upwind and downwind locations was conducted during each phase. The three municipal water supply wells were tested on multiple occasions, and onsite structures were wipe sampled[1].

The contamination was found to be limited to the upper surficial soils onsite. Significant concentrations of contaminants were not found in the subsurface below a one foot depth except in area S-7 where contamination above health based levels extended to an 18 inch depth[1].

Groundwater was not found in any of the soil borings drilled at the site. The stratigraphy underlying the surficial soil consists of two lithologic units of the El Pico Clay with permeabilities of 4×10^{-8} cm/sec and 1.5×10^{-8} to 3×10^{-9} cm/sec respectively.
The depth to the confined Carrizo Aquifer, the local source of municipal water, is approximately 700 feet in the vicinity of Crystal City. All samples collected from the three municipal wells completed in the Carrizo Aquifer at depths of 800 to 1000 feet did not indicate the presence of contaminants. The low permeability of the soils, the relative immobility of the contaminants, the lack of groundwater recharge areas, and the depth to groundwater effectively isolated the site contamination from the municipal water supply[4,5].

Offsite stream water, sediment, and surface samples were at or below background levels. However, offsite migration after a heavy rainfall event through surface water pathways was determined to be possible. Air sampling results did not indicate the presence of airborne contamination. Building structure wipe tests did not indicate significant contamination[1].

Extensive surficial soil contamination was identified in the vicinity of hangar buildings that had been occupied by aerial spraying operators. Maximum contaminations of indicator compounds measured in these areas were: 1,100 ppm toxaphene, 2,300 ppm DDT, and 1,450 ppm arsenic. The approximate volume of contaminated soils above 100 ppm combined contaminants was estimated to be 12,000 cubic yards[4].

Pre-ROD Community Relations Activities. Public notice of the August 20, 1987 ROD public meeting and comment period was announced via a news release on July 24, 1987, and published by the local county newspaper. A fact sheet describing the history of the site, the RI/FS results and the alternatives under consideration was issued to the public on August 10, 1987. The public meeting on August 20 was attended by approximately 45 citizens. At the request of concerned citizens the public comment period was extended to September 14, 1987[4].

Record of Decision. The ROD was signed on September 28, 1987 by the Regional Administrator. The state of Texas concurred with the selected remedy. The selected remedy consisted of onsite consolidation of all soils exceeding 100 ppm total pesticides under a RCRA cap. Public access to the consolidation cell would be restricted with protective fencing. Deep-well injection of decontamination liquids, a thirty year monitoring period and a five year review were also specified. The selected remedy was found to be fully protective of human health and the environment[4].

Toxaphene, Arsenic, and DDT were the contaminants of primary concern due to their widespread distribution, toxicity, and high concentrations relative to other compounds detected. The risk

assessment utilizing these three compounds resulted in a health based action level of 100 ppm total pesticides. Target receptors were identified as airport workers, travellers, and nearby residents. Exposure pathways were determined to be direct contact with contaminated soils through dermal contact, ingestion or airborne dust inhalation. Future land use was projected to continue as a municipal airport. This action level approaches a 1.0×10^{-6} risk level for onsite exposure through the identified pathways and was approved by the Agency for Toxic Substances and Disease Registry[5,6].

Remedial Design Activities. The funds to conduct the Remedial Design (RD) were awarded to the state of Texas on March 31, 1988 through a Cooperative Agreement with the TWC. On June 14, 1988, the TWC entered into a contract with Ebasco Services, the engineering firm that had conducted the RI/FS, to perform the RD work. In addition to preparing detailed technical plans and specifications for bid, Ebasco's scope of work included the following RD phase engineering tasks[7]:

- Perform rigorous bid quantity calculations,
- Generate an engineering cost estimate,
- Conduct geotechnical analyses of remedy components,
- Perform pavement design calculations,
- Determine onsite building decontamination methods,
- Develop action level verification protocol,
- Design materials handling and excavation procedures,
- Compile detailed health and safety and QA/QC requirements,
- Develop runoff control measures,
- Design air monitoring protocol,
- Generate construction sequence and schedule estimate.

Supplemental field data collected during the RD phase consisted of[7]:

- Additional site surveying for horizontal and vertical control,
- Defining subsurface conditions in the area of the consolidation cell,
- Geotechnical tests of soils representing cell contents and cap material.

The design phase was placed on an expedited timeframe due to high public interest and was completed in January of 1989. The TWC entered into a Construction Management contract with Ebasco for oversight services during the RA on March 7, 1989.

Remedial Construction Activities. The TWC published an Invitation for Bids (IFB) on January 31, 1989[8]. Eleven qualified bids were received with bid totals ranging from $1.091M to $2.241M, and averaging $1.696M. The contract was awarded to the lowest qualified bidder, Qualtec, Inc, and was executed by the TWC on April 21, 1989. Qualtec's submittals were finalized by June of 1989 and the contractor attempted to mobilize onsite but was denied entry by local officials. After repeated requests for access on behalf of Qualtec by both the EPA and TWC, a 104 Unilateral Administrative Order (UAO) was issued to Crystal City by the EPA for unconditional site access. The city complied in November 1989 and the TWC issued a Notice to Proceed to Qualtec on January 5, 1990. Qualtec began onsite mobilization on February 5, 1990.

During the 120 day construction activity period, the following remedial activities were conducted[9]:

- construction of the consolidation cell,
- excavation and consolidation of contaminated material in the cell,
- verification monitoring,
- placement, compaction, and grading of clean backfill,
- stormwater control,

- building decontamination, and asphalt floor removal,
- demolition of building B-3,
- reconstruction of airport facilities to approximate existing conditions,
- construction of the RCRA cap over the consolidation cell per the specifications and consisting of:

  1 foot depth of clean clay temporary cover,
  2 foot depth of compacted, highly impermeable clay,
  30 mil thick HDPE impermeable liner, with pressure tested hot wedge welds,
  1 foot depth of granular drainage material,
  1 layer of geotextile,
  2 foot depth of compacted soil with native vegetation topcover,

- continuous air monitoring and dust control,
- continuous health and safety and QA/QC operations.
- construction of a security fence around the consolidation cell.

The analyses performed during the RA phase verifying the ROD specified action levels for soils and demonstrating protectiveness in other media can be divided into five areas: air, water, soils, structures, and other issues.

1. **Air.** Air monitoring was conducted during onsite activities with fixed PM_{10} stations at the site boundaries employing 10 micron impaction filters. Background air monitoring was conducted prior to the initiation of site work. The particulate filters were analyzed for the contaminants of concern on a regular basis according to EPA established procedures and the results were compared to background levels. At no point in the project was the particulate action level of 1.0 mg/m^3 exceeded at the perimeter devices. Air quality was also verified periodically and during key remedial activities with hand held real time instrumentation including a handheld aerosol monitor (HAM) for particulate measurements, and a combustible gas indicator (CGI) for combustion hazards. Airborne hydrocarbon monitoring was conducted with both a photoionization detector (PID) and an organic vapor analyzer (OVA). Personnel exposure monitoring was conducted with mobile personal impaction filter devices. All personnel monitoring results were below the permissible exposure limits (PEL) as set by the Occupational Safety and Health Administration (OSHA) for the primary contaminants[9].

2. **Water.** A carbon adsorbtion water treatment unit was mobilized to the site by Qualtec as described in their approved Contaminated Runoff Control Plan. During construction, all surface water and decontamination liquids were carefully controlled onsite in a series of berms per the design specifications. Contaminated water was allowed to evaporate from the stormwater control berms. Evaporation residues were excavated and placed in the cell. Because of adequate onsite water control, no water was transported off-site for deep-well injection, and no water was discharged off-site to surface bodies. Sanitary sewage waste was handled separately and disposed in accordance with all proper state and local regulations[9].

3. **Soils.** A total of 104 soil verification samples and 8 soil composites were taken in accordance with the design specifications. Each area of the site defined on the construction plans was separately verified immediately after excavation under the close supervision of the TWC and/or the TWC's representative. Areas S-9 and S-10 were sampled before excavation per the specifications and were determined to be below the action level. Samples were taken in the center of each excavated area on approximately a 150' X 150' grid. Samples were also taken at the perimeter face of each excavation at approximately 200' intervals. Sample locations were surveyed before backfilling. All sample results were below the ROD specified

action levels at the verification depth as specified in the design. The verification depth was 12 inches throughout the site except in area S-7, which, due to slightly deeper contamination identified during the remedial investigation, required an 18 inch verification depth[9].

4. **Structures.** All structures in the contamination zones were steam cleaned in accordance with the design specifications and EPA's guidance for building decontamination at Superfund sites. Surface trash was removed before steam cleaning. Asphaltic floor slabs were removed and replaced with concrete. Wipe samples taken in each decontaminated structure verified the building decontamination action level had been met[9].

5. **Other Issues.** Special verification monitoring was conducted immediately after the transfer of the buried material in the temporary removal action pits into the consolidation cell. On March 14, 1990, immediately after the transfer, real time portable instrumentation and carbon tubes samplers were utilized downwind to verify air quality. On April 19, 1990, approximately 15 to 20 empty five gallon containers were found buried in a shallow pit behind Frank's hangar. The soil in a 12.5 foot radius around the containers to a 2 foot depth was excavated and placed in the consolidation cell. The verification soil samples of this pit were additionally tested for the label contents of the drums. The verification results were below the total pesticide action level specified in the ROD[9].

QA/QC of Construction Activities. All project submittals from the Oversight Engineer, Ebasco, and the Construction Contractor, Qualtec, were carefully reviewed by the TWC and EPA for completeness, accuracy and compliance with all TWC and EPA quality assurance and quality control protocol. Qualtec's submittals were also reviewed in this manner by Ebasco as part of Ebasco's oversight responsibilities[9].

Qualtec's QA/QC activities during construction conformed with their approved pre-construction submittals including:

- Laboratory Quality Management Plan,
- Quality Control Management Plan.

All delivered construction materials used during the remediation were subject to strict quality documentation. Photodocumentation was used during the RA phase as an additional quality indicator[9].

Ebasco's site activities throughout their association with the project conformed to their Quality Assurance and Quality Control Plan for the Crystal City Airport Superfund Site. During the Remedial Action phase, Ebasco provided construction oversight services on behalf of the TWC. Ebasco maintained a continual presence at the site to monitor the compliance and QA/QC activities of the construction contractor, Qualtec. Daily work progress and QA/QC meetings were held between Ebasco and Qualtec representatives at the site. In addition, weekly meetings were held with Qualtec, Ebasco, and TWC representatives. Minutes of these meetings can be found in the appendices to the RA Report[9].

Ebasco split approximately 10% of the critical verification samples as a quality assurance check. Qualtec also split verification samples with a separate lab to provide an internal quality assurance check on its prime lab subcontractor.

Pre-final inspections were held on May 31, 1990 and June 6, 1990 to close out site work. The Certificate of Substantial Completion was issued July 3, 1990, signifying the completion of all work except the vegetative topcover growth required by the contract specifications. The final work product

acceptance occurred on September 25, 1990 after a joint EPA and State inspection indicated the vegetative requirements had been met. After a number of revisions, the RA Report is projected to be finalized and approved by the regional administrator by the third quarter of fiscal year 1991.

Post-ROD Community Relations Activities. Public fact sheets were published after significant RD milestones and during each month of the RA phase. The RA phase fact sheets described the site work completed to date and the upcoming construction activities planned for the following month. Separate monthly progress reports were provided to local city officials also detailing RA activities. Various briefings were held with the city manager throughout the RA phase. Additional briefings of the Crystal City council were conducted periodically at its request by the TWC and EPA. City officials were hosted on a site tour during a pre-final inspection. A public open house was held onsite in the clean zone every Wednesday during construction by either TWC and/or EPA representatives to allow public access to the responsible government officials. A toll free 1-800 line to the EPA offices was also provided and advertised to the local public. A viewing platform was built in the clean zone for interested residents to view site activities from a safe distance. The viewing platform was later donated to the city. The EPA project manager attended a local Lions Club meeting and presented a brief history of the remedial efforts conducted at the site.

Operational and Functional Period. The first year of the thirty year Operation and Maintenance period was defined as the Operational and Functional (O&F) period by the state and the region. A cooperative agreement for the first year of O&M was executed in June of 1990 to provide 90% federal and 10% state funding to ensure the remedy proved to be O&F through four quarterly inspection events. The scope of work for the O&F period included sampling of the city water for primary contaminants, maintenance of the cell vegetative topcover, inspection of the cell fence and air monitoring during the first and fourth quarters[10]. The TWC amended their oversight contract with Ebasco Services in September, 1990 to include the O&F work. The TWC issued Ebasco a Notice to Proceed in October, 1990. The O&F visits will be conducted on the following dates:

1) November 8, 1990
2) February 6, 1991
3) May 7, 1991
4) August 5, 1991

The TWC and the EPA have discussed the criteria that will prove the remedy is operational and functional. Contaminants of concern should not be detected above health based limits in any city water samples nor in any air monitoring samples taken during the O&F period. The cap should remain intact, undisturbed, and operational. Vegetative topcover over the cell should be controlled and healthy. Security fencing surrounding the cell should be performing as designed to restrict access to the cell.

Operations and Maintenance. Following the demonstration of O&F, the TWC will continue to monitor the site during the thirty year O&M phase to ensure the remedy continues to be protective of human health and the environment.

Five year review. Since restricted areas where waste is controlled remain onsite, a five year review will be conducted by the TWC and EPA. The five year review will be conducted to ensure the remedy continues to be operational and functional and protective of human health and the environment. The five year review of the selected remedy will be conducted after July 1995, five years after the Substantial Completion of the Remedial Action for the single and final operable unit at this site on July 3, 1990.

DISCUSSION

A recent Agency initiative has been to more accurately define the status of projects that are moving through and past the RA phase. This is in response to public frustration over the seeming lack of progress in the Superfund program as gauged by the number of sites that have been removed from the NPL since the program began. Depending on the site, the NPL delisting process may not begin until a five year review has been conducted[11]. The relatively limited Agency experience in completing RAs has led to somewhat of a vacuum in precedence. The combination of these items has led to many post-RA sites staying on the NPL well after onsite activities are complete for various regulatory reasons, hence contributing to the apparent lack of progress. Many more sites will be proceeding into this post-RA stage in the next few years. Some guidance is currently available[11].

The delisting stage could arguably be the most important phase in the Superfund process as the Agency presents the public resolution to all site issues developed throughout the site's history. The Agency's explanation of remedial progress could perhaps be better expressed to the public with more effective milestone tracking of sites proceeding to delisting. Useful milestone definitions would both contribute to the program's uniformity and aid in progress tracking. For this reason, the current 1991 SCAP milestone definitions[12] will be compared to actual dates achieved and projected at the Crystal City Airport site. Although the definitions presented below specifically apply to a fund-financed state-lead site, and may be interpreted slightly differently on a regional basis, the issues raised may be of general programmatic interest.

RA Award. This activity is defined as the award of the contract for remedial construction services[12]. Currently, only the completion date is tracked. Often, the time period between the publication of the request for bids and the award date may extend over a few months, particularly if a two-step qualifications based procurement is utilized for a complex project. A more effective use of this SCAP line item might be to define the RA Award start as the date of publication of the request for bids, and RA Award complete as the date of an executed contract. At the Crystal City Airport site, a one-step procurement of a non-complex remedial construction, bids were solicited on January 31, 1989, and the contract was executed April 21, 1989.

RA On-Site Construction. This activity is also a single date event, currently defined as the initiation of onsite mobilization by the RA construction contractor[12]. However, a significant project milestone, the demobilization of the construction contractor from the site (i.e. the completion of onsite construction activities) is currently not tracked by the SCAP. Both of these dates could easily be tracked by this SCAP line item as RA On-Site Construction start and RA On-Site Construction complete respectively.

At the Crystal City, contractor mobilization occurred on February 5, 1990, and contractor demobilization occurred on July 9, 1990.

Operational and Functional. This is a new SCAP milestone for FY 1991. The definition for this period parallels the definition found in Section 300.435(f)(2) of the NCP which states:

> A remedy becomes "operational and functional" either one year after construction is complete, or when the remedy is determined concurrently by EPA and the state to be functioning properly and is performing as designed, whichever is earlier. EPA may grant extensions to the one-year period as appropriate.

One issue that has recently been raised in Region 6 is whether the term "remedy" in the above definition applies to the completion of each operable unit at a site, or strictly to the completion of the final operable unit. The definition of accomplishment for this period is the Regional approval of

either the Operable Unit RA Report or the Closeout Report, whichever is appropriate[12]. The O&F period is therefore a discrete part of the Remedial Action phase by definition and occurs post-construction. As mentioned above, contractor demobilization from the Crystal City Airport site occurred on July 9, 1990. A joint state and federal inspection of the site and acceptance of the constructed remedy occurred on September 25, 1990. The O&F period for the Crystal City site has been defined by both the state and the region to extend for up to one year after this date. By September of 1991, the state and the EPA will have conducted four quarterly site inspections to monitor the air and groundwater quality at the site to determine the remedy's operationality and functionality. The Closeout Report is currently projected for completion in the 1st quarter of fiscal year 1992, with regional approval by the 2nd quarter of 1992.

One suggestion for applying the current definitions of O&F on Superfund projects is to incorporate the language and terminology of the Agency's O&F period into the contracting agency's agreement with the contractor. For example, the TWC's Superfund construction contracts include standard boilerplate requirements based on Construction Specifications Institute (CSI) language for a one-year post-construction warranty period and the final inspection/work acceptance protocol. If the work is partially funded through an EPA grant, the federal project manager would be well served by ensuring that the non-federal lead contract contains job completion verbiage and milestone definitions parallel to those of the federal Superfund program. Generally, while the EPA is not a formal party to such agreements, they are reviewed and approved by the Agency. Foresight for post-construction issues during the approval process could be invaluable at a future date.

RA Completion, First, Subsequent, and Final. This milestone event is currently defined as the approval by the Regional Administrator of the Operable Unit Remedial Action Report for a non-final operable unit at a given site, or the approval of the Closeout Report for a final operable unit at a given site[12].

A brief explanation of the region's differentiation in practice between a Remedial Action Report (RA Report) and a Closeout Report is relevant. The RA Report is generated by the Construction Oversight entity[11], which is generally the engineering firm that performed the RI/FS, and RD for the site. At the Crystal City Airport, the Oversight Engineer maintained a continual presence at the site throughout all RA activities to ensure the work was performed by the Construction Contractor as specified. The Construction Contractor was responsible for all required project documentation. The Oversight Engineer provided a second party verification of the documentation and compiled it into the RA Report. The RA Report summarizes the RA activities and demonstrates that the remedy was implemented in accordance with the ROD. This document also contains written certification from both the Oversight Engineer and the Construction Contractor that the work was completed according to the specifications. In general, an RA Report is generated for each operable unit at a site[11]. An RA Report may or may not include a determination that a remedy has been demonstrated as O&F depending how the O&F period is defined. Since the O&F period was defined by the state and the region to extend up to one year at Crystal City, the Crystal City Airport RA Report does not make a representation of O&F[9]. The determination of O&F will be jointly made by the state and the region upon completion of the O&F period and will be based on recommendations of the Oversight Engineer made during the O&F period. The table of contents for the Crystal City Airport RA Report can be found as an attachment.

A site Closeout Report is an inherently governmental task, and may be written by either the EPA or the lead agency, but should be approved by both. Only one Closeout Report is generated per NPL site--after the completion of the final operable unit RA[11]. The Closeout Report is the Agency's public representation that all actions necessary to protect human health and the environment have been completed. Since only one operable unit exists at the Crystal City Airport a Closeout Report will be generated at the completion of the (only) Remedial Action, which in this case will occur

concurrently on the completion date of the O&F period. The O&F period will be documented in the Closeout Report for the Crystal City Airport.

The definition of Remedial Action completion specifies that the remedial action is operational and functional (O&F) at this milestone[11,12]. As defined above, the O&F period may extend up to one year after contractor demobilization. Additionally, the generation of the Closeout Report and joint state and federal concurrence on the status of the site may delay regional approval of the Closeout Report for a period of time after the O&F period. Thus, at Crystal City, the strict SCAP definition of RA completion is projected to occur up to approximately 20 months after the contractor demobilized and actual site work was completed.

Operations and Maintenance. The O&M phase is defined to begin upon completion of the Remedial Action[12]. According to this definition, the O&M start date should coincide with the RA completion date.

Long Term Remedial Action (LTRA). An LTRA is defined as a response action taken for the purpose of restoring ground or surface water quality[12]. The current definition is somewhat ambiguous, but it has been implemented as follows for a fund-financed, state-lead, groundwater treatment remedy in Region 6: The "RA" portion of the project will be defined as the construction of the surface facilities, well network, and other equipment necessary to conduct the pump and treat remedy. The "RA" has been placed in quotations due to somewhat confusing terminology of LTRA sites. The start and complete dates of this portion of the project have been defined to be the date of RA funding and the date of demonstrated O&F respectively. The O&F period will initiate upon the final acceptance of the constructed equipment and consist of a verification period that proves the performance specifications of the equipment have been met. At that point an Interim LTRA Report will be prepared much like an RA Report that documents the completion of the "RA" portion. The actual period of groundwater treatment that may take up to 10 years will occur during the "LTRA" portion of the project. A Final LTRA Report will be generated at the completion of the LTRA and will include the Interim LTRA Report as an appendix. The completion of the LTRA operable unit will be achieved with regional and state approval of the Final LTRA Report. O&M activities for this operable unit will then commence upon the approval of the Final LTRA Report. The guidance suggests that the combined Interim and Final LTRA Reports may constitute the Closeout Report for the site[11]. Example formats for a Region 6 Interim LTRA Report and a Final LTRA Report can be found as attachments.

Initiation of NPL Deletion. This is the only other delisting milestone that is currently tracked for fund-lead sites. The start of this task is credited upon the publication of the Notice of Intent to Delete in the Federal Register[12]. If wastes are left in restricted areas onsite as in the case of Crystal City, current policy requires a five year review before initiating the delisting process[11]. If a site is an LTRA site, delisting would currently be initiated after the long-term treatment has been concluded[11].

CONCLUSIONS

The fund-financed state-lead construction activities at the Crystal City Airport site in Crystal City, Texas have been completed. Pesticide contaminated soils above health based action levels have been excavated and consolidated onsite beneath a RCRA cap. The threat to human health and the environment has been effectively mitigated. Beyond the restricted area of the consolidation cell, unrestricted use of the airport facilities has been returned to the local city government. O&F activities for the single operable unit at the site are underway and will continue until the late summer of 1991. A determination of the site's O&F status and continued protectiveness will be made at that time by both the state and the region. The RA Report has been submitted by the Oversight Engineer

and is currently under review by both the state and the region. A Closeout Report will be drafted by the EPA after the completion of the O&F period.

The answer to the question, "When will the Crystal City Remedial Action be complete?" depends on the degree of detail required by the questioner. The answer that follows invites the questioner to choose his/her preference:

On-site construction:	complete 7/9/90
Substantial final completion:	complete 7/9/90
Contractor demobilization:	complete 7/9/90
Growth of vegetative topcover:	complete 9/25/90
Final state/regional inspection:	complete 9/25/90
State/regional approval of RA Report:	projected complete 5/1/91
O&F activities:	projected complete 11/1/91
State/regional apprvl of Closeout Rep:	projected complete 3/30/92
SCAP definition of O&F period:	projected complete 3/30/92
SCAP definition of RA phase:	projected complete 3/30/92
Initiation of O&M phase:	projected start 3/30/92

One aspect of the post-RA process that should not be underestimated is the importance of obtaining the consensus and input of all parties involved with the site. If care is not taken to continue to promote consensus during the post-ROD period, a site may face the undesirable prospect of indefinite listing. The decision to delist is a "meeting of the minds" between the state and federal governments that includes public input. The delisting process may be as involved or as complex as the selection of the remedy, particularly if a high profile or complex site is at issue. The complexity of the delisting is in part caused by the addition of all the post-ROD documentation involved in the RD and RA phases. One way in which consensus can be promoted is through documented joint state and federal determinations at each post-RA milestone. For example, the following questions should be defined in advance of the O&F period:

- What are the goals of the O&F period?
  Exactly what site conditions will determine when and if O&F has been achieved?
- Exactly what site conditions will prove O&F has not been achieved?
- What possible failure scenarios could occur and what are appropriate contingency plans?

Similar questions should be defined in advance of the five-year review even though Agency policy may evolve significantly:

- What level of five year review complexity is necessary?
- What is the scope of the five year review?
- When will the five year review occur?
- How will the five year review be funded?
- Who will conduct the five year review?

The Office of Emergency and Remedial Response is currently considering many of these five year review issues.

DISCLAIMER

This paper was prepared by the author for presentation at the May, 1991 Conference on Design and Construction Issues at Hazardous Waste Sites sponsored by the USEPA's Office of Emergency and

Remedial Response. This paper reflects the opinions of the author only. This paper does not contain either regional or national policy and should not be construed as such.

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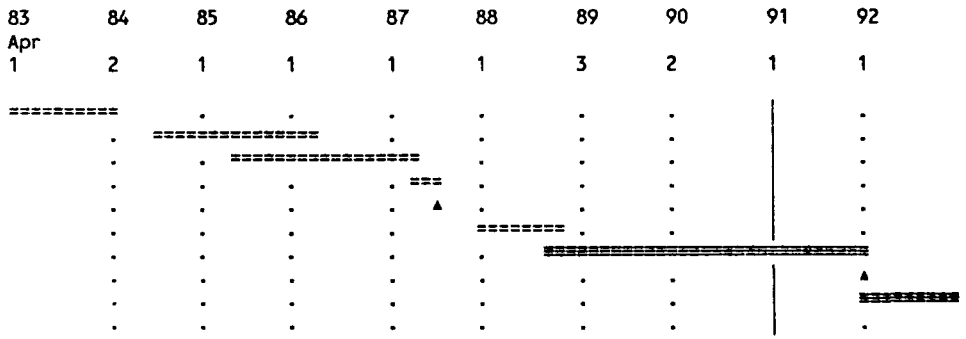
11. Procedures for Completion and Deletion of National Priorities List Sites, United States Environmental Protection Agency, Office of Emergency and Remedial Response, OSWER Directive 9320.2-3A, April 1989, as revised by OSWER Directive 9320.2-3B, December, 1989.

12. Superfund Program Management Manual, United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, OSWER Directive 9200.3-01D, June 1990.

Schedule Name : Crystal City Airport
Responsible : Bryon Heineman
As-of Date : 27-Mar-91

Task Name	Start Date	Duratn (Days)	End Date	Start Status
+ Pre-Listing Activities	1-Mar-83	292	24-Apr-84	Done
+ NPL Listing	5-Oct-84	406	19-May-86	Done
+ RI/FS	19-Aug-85	475	10-Jul-87	Done
+ ROD Process	24-Jul-87	36	14-Sep-87	Done
Record of Decision Signed	28-Sep-87	0	28-Sep-87	Done
+ Remedial Design	31-Mar-88	201	18-Jan-89	Done
+ Remedial Action	29-Dec-88	832	26-Mar-92	Started
Regional Appvl of Closeout Rep	27-Mar-92	0	27-Mar-92	Future
+ Operations and Maintenance	27-Mar-92	5,657	9-Oct-14	Future
+ Site Deletion	3-Jul-95	485	6-Jun-97	Future



Detail Task ===== Summary Task ••••• Baseline
(Progress) ==== (Progress) ▸▸▸ Conflict
(Slack) ===— (Slack) Resource delay
Progress shows Percent Achieved on Actual ▲ Milestone
Scale: 6 weeks per character

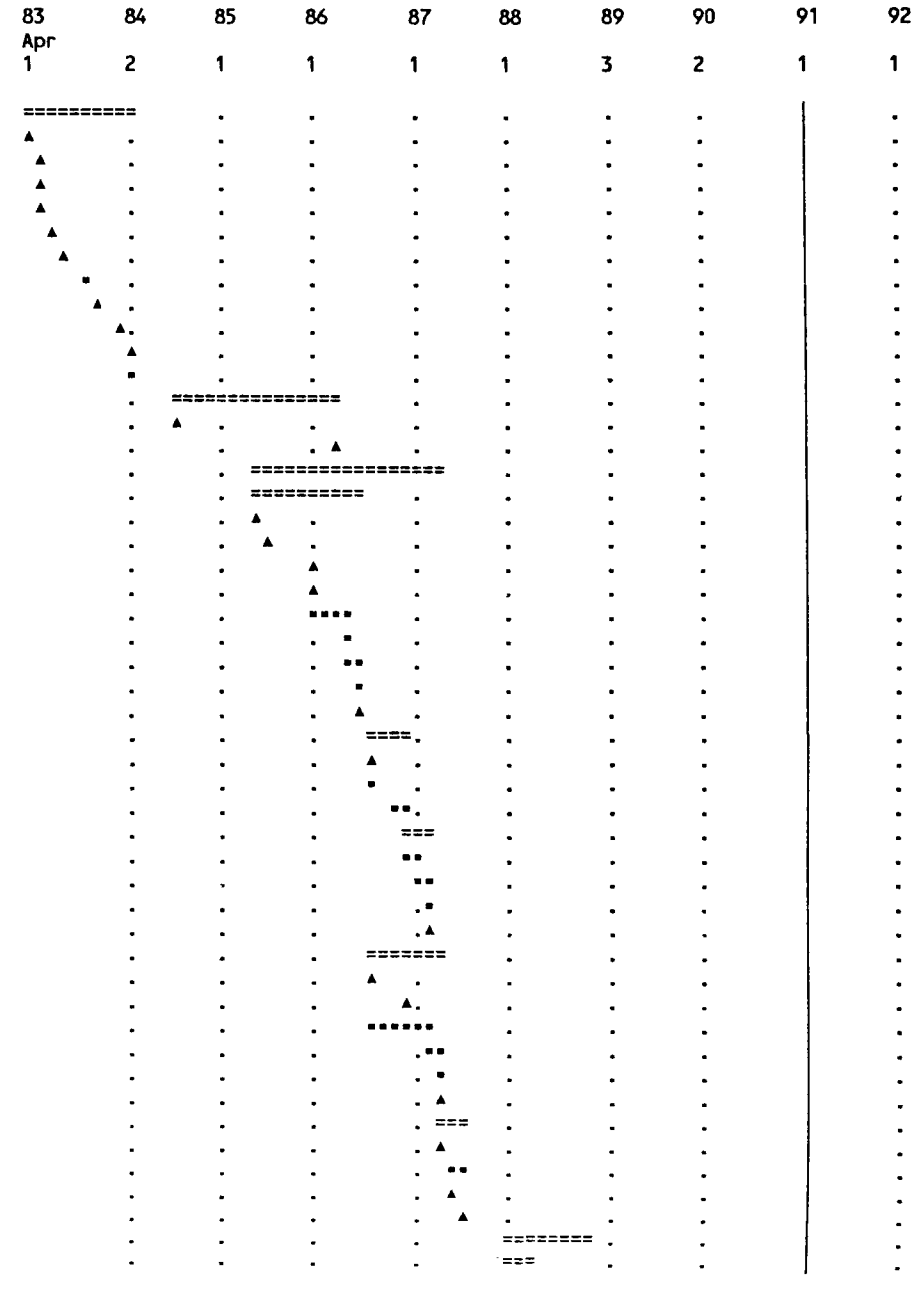
TIME LINE Gantt Chart Report, Strip 1

ATTACHMENT A

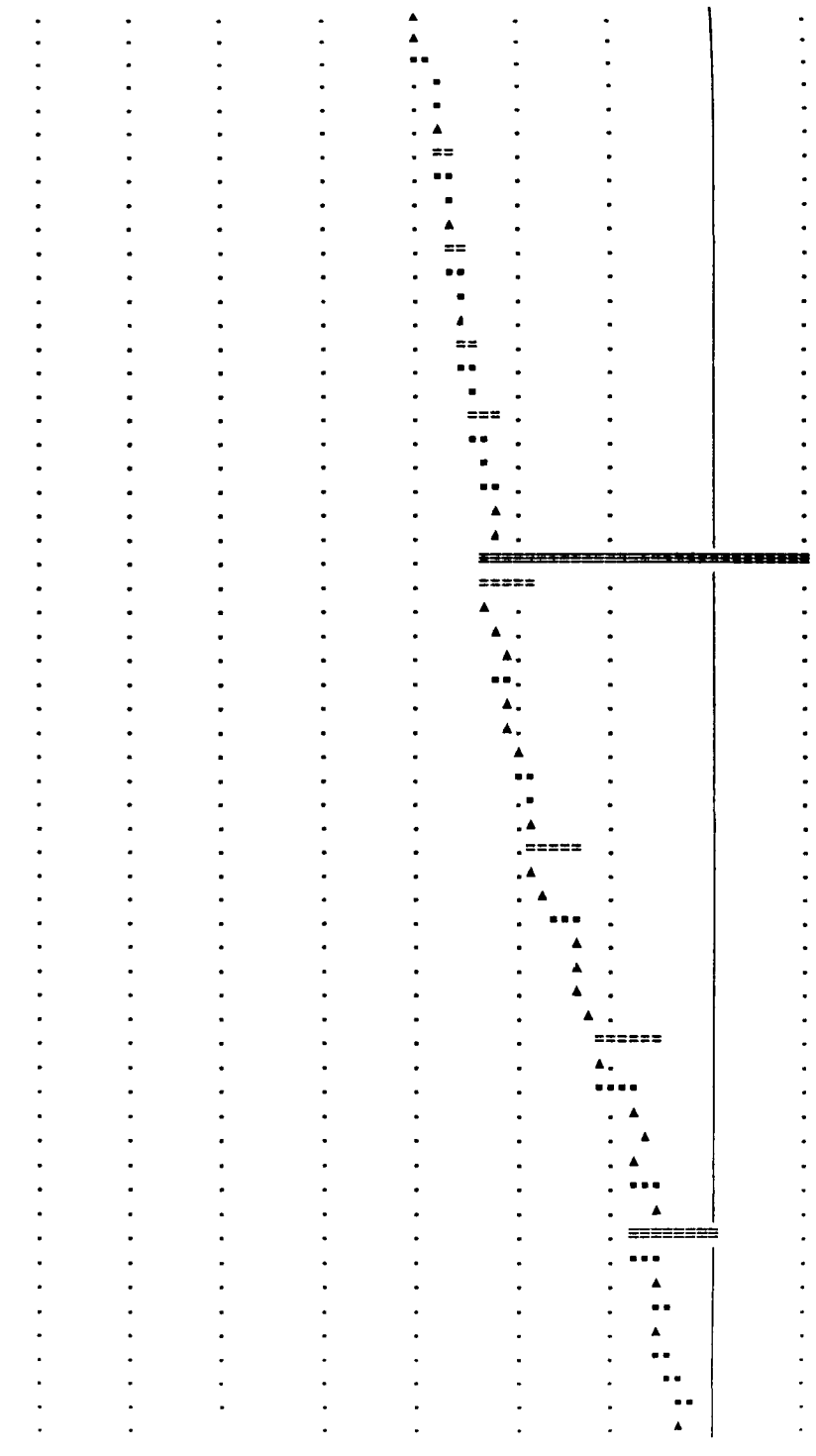
Crystal City Airport Project
Schedule

Schedule Name : Crystal City Airport
Responsible : Bryon Heineman
As-of Date : 27-Mar-91

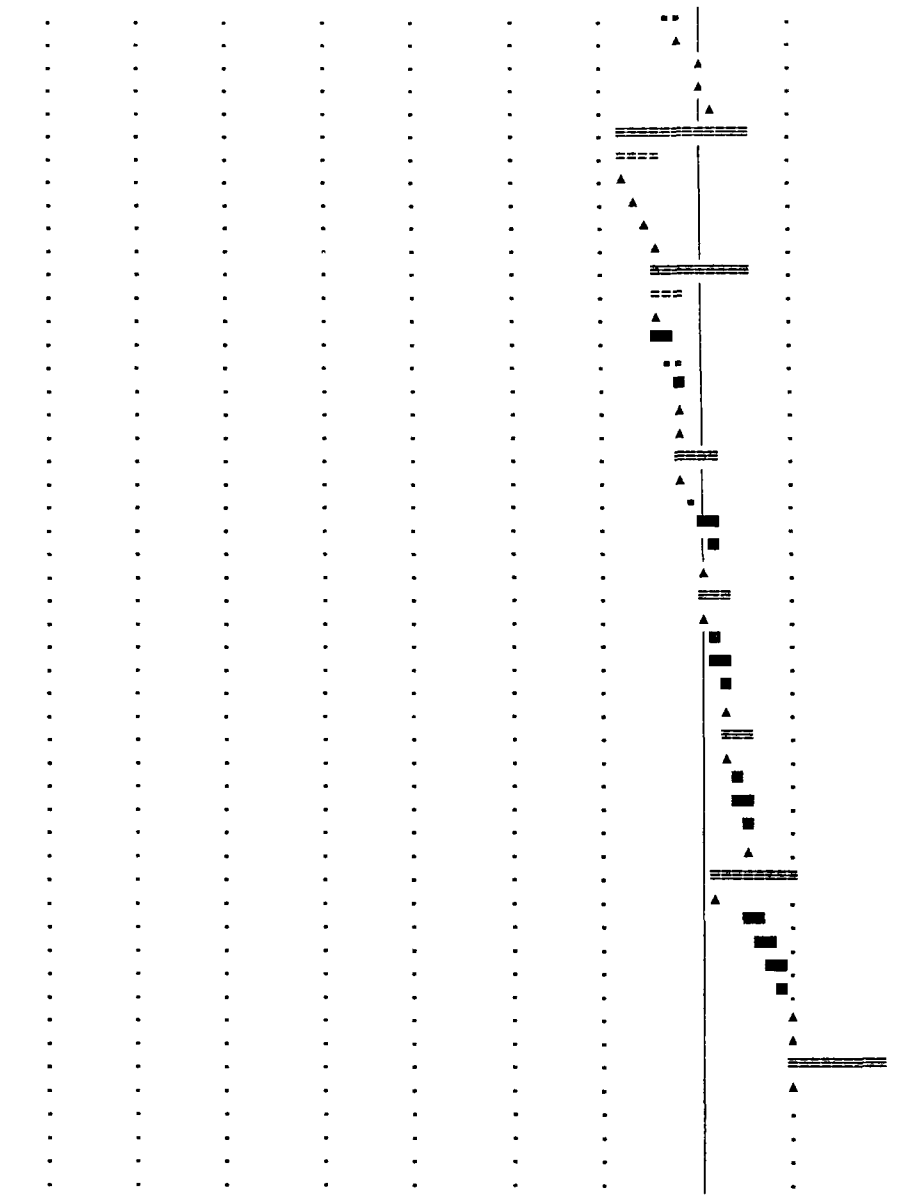
Task Name	Start Date	Duratn (Days)	End Date	Start Status
Pre-Listing Activities	1-Mar-83	292	24-Apr-84	Done
Site Abandonment by Operators	1-Mar-83	0	1-Mar-83	Done
Local Identification	21-Apr-83	0	21-Apr-83	Done
Initial TWDR Investigation	25-Apr-83	0	25-Apr-83	Done
TWDR Site Visit	5-May-83	0	5-May-83	Done
TWDR/EPA Prelim Sampling	13-Jun-83	0	13-Jun-83	Done
EPA Soil Sampling	25-Jul-83	0	25-Jul-83	Done
Initial Removal Action	31-Oct-83	3	2-Nov-83	Done
Verification Sampling	15-Dec-83	0	15-Dec-83	Done
Verfication Sampling	14-Feb-84	0	14-Feb-84	Done
Verification Sampling	29-Mar-84	0	29-Mar-84	Done
Subsequent Removal Action	23-Apr-84	2	24-Apr-84	Done
NPL Listing	5-Oct-84	406	19-May-86	Done
Site Proposed for NPL	5-Oct-84	0	5-Oct-84	Done
Site Promulgated on NPL	20-May-86	0	20-May-86	Done
RI/FS	19-Aug-85	475	10-Jul-87	Done
Project Planning	19-Aug-85	273	18-Sep-86	Done
Scoping Site Visit	19-Aug-85	0	19-Aug-85	Done
RI/FS Funds Awarded to TWC	25-Sep-85	0	25-Sep-85	Done
TWC Issues RFP	25-Feb-86	0	25-Feb-86	Done
RFPs Due at TWC	28-Mar-86	0	28-Mar-86	Done
TWC Awards RI/FS Contract	31-Mar-86	65	30-Jun-86	Done
Ebasco Drafts WP, QAPP, HSP	1-Jul-86	21	30-Jul-86	Done
EPA/TWC Review Workplans	31-Jul-86	18	25-Aug-86	Done
Ebasco Revisions	25-Aug-86	18	18-Sep-86	Done
EPA/TWC Approval	19-Sep-86	0	19-Sep-86	Done
RI Fieldwork	29-Sep-86	94	13-Feb-87	Done
Onsite Mobilization	29-Sep-86	0	29-Sep-86	Done
Phase I Fieldwork	30-Sep-86	23	31-Oct-86	Done
Phase II Fieldwork	28-Jan-87	13	13-Feb-87	Done
RI Report	17-Feb-87	74	1-Jun-87	Done
Draft RI Report	17-Feb-87	36	7-Apr-87	Done
EPA/TWC Review RI Report	8-Apr-87	21	6-May-87	Done
Ebasco Revises RI Report	7-May-87	17	1-Jun-87	Done
Final RI Report	2-Jun-87	0	2-Jun-87	Done
FS Report	25-Sep-86	198	10-Jul-87	Done
FS Authorized	25-Sep-86	0	25-Sep-86	Done
FS Objectives Approved	27-Feb-87	0	27-Feb-87	Done
Ebasco Drafts FS Report	25-Sep-86	160	15-May-87	Done
EPA/TWC Review FS Report	18-May-87	19	12-Jun-87	Done
Ebasco Revises FS Report	15-Jun-87	19	10-Jul-87	Done
Final FS Report	13-Jul-87	0	13-Jul-87	Done
ROD Process	24-Jul-87	36	14-Sep-87	Done
Public Notice	24-Jul-87	0	24-Jul-87	Done
Extended Comment Period	27-Jul-87	35	14-Sep-87	Done
Public Meeting	20-Aug-87	0	20-Aug-87	Done
Record of Decision Signed	28-Sep-87	0	28-Sep-87	Done
Remedial Design	31-Mar-88	201	18-Jan-89	Done
Project Planning	31-Mar-88	52	13-Jun-88	Done



RD CA Signed w/TWC	31-Mar-88	0	31-Mar-88	Done
TWC Receives RD SOW	1-Apr-88	0	1-Apr-88	Done
Ebasco/TWC Revise SOW	1-Apr-88	39	25-May-88	Done
EPA Reviews SOW	26-May-88	1	26-May-88	Done
Ebasco Revises SOW	27-May-88	6	6-Jun-88	Done
TWC/Ebasco Execute Contract	14-Jun-88	0	14-Jun-88	Done
30% Design Effort	15-Jun-88	42	12-Aug-88	Done
Ebasco Generates 30% RD	15-Jun-88	38	8-Aug-88	Done
EPA/TWC 30% Review	9-Aug-88	4	12-Aug-88	Done
30% RD Meeting	15-Aug-88	0	15-Aug-88	Done
60% Design Effort	16-Aug-88	23	16-Sep-88	Done
Ebasco Generates 60% RD	16-Aug-88	19	12-Sep-88	Done
EPA/TWC 60% Review	13-Sep-88	4	16-Sep-88	Done
60% RD Meeting	19-Sep-88	0	19-Sep-88	Done
95% Design Effort	20-Sep-88	29	31-Oct-88	Done
Ebasco Generates 95% RD	20-Sep-88	25	25-Oct-88	Done
EPA/TWC 95% Review	26-Oct-88	4	31-Oct-88	Done
100% Design Effort	1-Nov-88	51	17-Jan-89	Done
Ebasco Generates 100% RD	1-Nov-88	13	18-Nov-88	Done
EPA/TWC Review	21-Nov-88	23	22-Dec-88	Done
100% RD Revisions	23-Dec-88	15	17-Jan-89	Done
EPA Concurs w/100% RD	18-Jan-89	0	18-Jan-89	Done
Post-RD Open House	19-Jan-89	0	19-Jan-89	Done
Remedial Action	29-Dec-88	832	26-Mar-92	Started
Project Planning	29-Dec-88	111	7-Jun-89	Done
RA CA Signed w/TWC	29-Dec-88	0	29-Dec-88	Done
TWC Issues IFB	31-Jan-89	0	31-Jan-89	Done
Pre-Bid Conference	16-Feb-89	0	16-Feb-89	Done
Bid Period	31-Jan-89	29	13-Mar-89	Done
TWC Opens Bids	13-Mar-89	0	13-Mar-89	Done
TWC Signs A&E Contract	7-Mar-89	0	7-Mar-89	Done
TWC Signs Const. Contract	21-Apr-89	0	21-Apr-89	Done
Qualtec Drafts Submittals	21-Apr-89	17	15-May-89	Done
Submittals Finalized	16-May-89	14	5-Jun-89	Done
Pre-Construction Conf.	8-Jun-89	0	8-Jun-89	Done
Aquisition of Site Access	14-Jun-89	116	22-Nov-89	Done
TWC Denied Access	14-Jun-89	0	14-Jun-89	Done
TWC Requests EPA Assist	13-Jul-89	0	13-Jul-89	Done
EPA Drafts 104 UAO	23-Aug-89	52	2-Nov-89	Done
City Receives UAO	6-Nov-89	0	6-Nov-89	Done
EPA/City UAO Meeting	17-Nov-89	0	17-Nov-89	Done
Effective Date of UAO	23-Nov-89	0	23-Nov-89	Done
TWC Issues NTP	29-Dec-89	0	29-Dec-89	Done
Field Work	5-Feb-90	167	25-Sep-90	Done
Mobilization	5-Feb-90	0	5-Feb-90	Done
Construction Activities	5-Feb-90	104	28-Jun-90	Done
Pre-Final Inspection	6-Jun-90	0	6-Jun-90	Done
Final Inspection	9-Jul-90	0	9-Jul-90	Done
Substantial Completion	3-Jul-90	0	3-Jul-90	Done
Vegetative Topcover Growth	28-Jun-90	64	25-Sep-90	Done
Final Completion	25-Sep-90	0	25-Sep-90	Done
RA Report	3-Jul-90	213	26-Apr-91	Started
Prep of Draft RA Report	3-Jul-90	48	6-Sep-90	Done
Ebasco Submits Draft to TWC	30-Aug-90	0	30-Aug-90	Done
TWC Review of Draft RA Rep.	31-Aug-90	26	5-Oct-90	Done
EPA Receipt of Draft RA Rep.	7-Sep-90	0	7-Sep-90	Done
EPA Review of Draft RA Rep.	10-Sep-90	19	4-Oct-90	Done
Revision of RA Rep. by Ebasco	5-Oct-90	46	7-Dec-90	Done
TWC Review of Revised RA Rep.	10-Dec-90	35	25-Jan-91	Done
EPA Receipt of Revised RA Rep	18-Dec-90	0	18-Dec-90	Done



EPA Review of Revised RA Rep.	18-Dec-90	10	31-Dec-90	Done
EPA Receipt of As-Builts	25-Jan-91	0	25-Jan-91	Done
Final Qualtec Documentation	1-Apr-91	0	1-Apr-91	Future
TWC Approval of RA Report	1-Apr-91	0	1-Apr-91	Future
Regional Approval of RA Rep.	29-Apr-91	0	29-Apr-91	Future
First Yr O&M = RA O&F Period	6-Jun-90	347	9-Oct-91	Started
Planning	6-Jun-90	88	5-Oct-90	Done
1st Yr O&M CA Signed (O&F)	6-Jun-90	0	6-Jun-90	Done
EPA Concurs w/O&M/O&F SOW	1-Aug-90	0	1-Aug-90	Done
TWC Signs O&M/O&F Contract	17-Sep-90	0	17-Sep-90	Done
TWC Issues NTP to Ebasco	8-Oct-90	0	8-Oct-90	Done
Monitoring Activities	1-Oct-90	264	9-Oct-91	Started
1st Quarter O&M/O&F	1-Oct-90	70	7-Jan-91	Done
Beginning of Quarter	1-Oct-90	0	1-Oct-90	Done
Site Visit	8-Nov-90	2	9-Nov-90	Done
Trip Report	12-Nov-90	36	31-Dec-90	Done
TWC/EPA Review	2-Jan-91	3	7-Jan-91	Done
End of Quarter	31-Dec-90	0	31-Dec-90	Done
Public Update	23-Jan-91	0	23-Jan-91	Done
2nd Quarter O&M/O&F	1-Jan-91	105	29-May-91	Started
Beginning of Quarter	1-Jan-91	0	1-Jan-91	Done
Site Visit	6-Feb-91	2	7-Feb-91	Done
Trip Report	27-Mar-91	35	14-May-91	Future
TWC/EPA Review	15-May-91	10	29-May-91	Future
End of Quarter	29-Mar-91	0	29-Mar-91	Future
3rd Quarter O&M/O&F	1-Apr-91	73	12-Jul-91	Future
Beginning of Quarter	1-Apr-91	0	1-Apr-91	Future
Site Visit	7-May-91	2	8-May-91	Future
Trip Report	9-May-91	35	27-Jun-91	Future
TWC/EPA Review	28-Jun-91	10	12-Jul-91	Future
End of Quarter	28-Jun-91	0	28-Jun-91	Future
4th Quarter O&M/O&F	1-Jul-91	71	9-Oct-91	Future
Beginning of Quarter	1-Jul-91	0	1-Jul-91	Future
Site Visit	5-Aug-91	2	6-Aug-91	Future
Trip Report	7-Aug-91	35	25-Sep-91	Future
TWC/EPA Review	26-Sep-91	10	9-Oct-91	Future
End of Quarter	30-Sep-91	0	30-Sep-91	Future
Closeout Report	1-May-91	228	26-Mar-92	Future
TWC Submits Project Document.	1-May-91	0	1-May-91	Future
Draft Closeout Report	10-Oct-91	20	6-Nov-91	Future
TWC Review of Closeout Rep.	7-Nov-91	40	7-Jan-92	Future
Closeout Report Revisions	8-Jan-92	25	12-Feb-92	Future
TWC Concurrence	13-Feb-92	10	27-Feb-92	Future
Regional Appvl of Closeout Rep	27-Mar-92	0	27-Mar-92	Future
Regional Appvl of Closeout Rep	27-Mar-92	0	27-Mar-92	Future
Operations and Maintenance	27-Mar-92	5,657	9-Oct-14	Future
State Begins O&M	27-Mar-92	0	27-Mar-92	Future
End of Thirty Year Period	10-Oct-14	0	10-Oct-14	Future
Site Deletion	3-Jul-95	485	6-Jun-97	Future
Five Year Review	3-Jul-95	120	22-Dec-95	Future
Administrative Requirements	26-Dec-95	365	6-Jun-97	Future



Detail Task — Summary Task — Baseline
(Progress) — (Progress) — Conflict
(Slack) — (Slack) — Resource delay
Progress shows Percent Achieved on Actual — Milestone
Scale: 6 weeks per character

TIME LINE Gantt Chart Report, Strip 1

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ATTACHMENT B

Crystal City Airport RA Report Contents

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B	Field Orders
C	Change Orders
D	Nonconformance Reports
E	Substantial Completion Documentation
F	Construction Cost Documentation
G	Health and Safety Summary Report
H	Chemical Quality Control Project Summary Report
I	Engineer's Weekly Progress Reports
J	Construction Quality Control Daily Reports
K	Weekly Progress Meeting Minutes
L	Non-Construction Issues
M	Operations and Maintenance Plan
N	Record of Decision (ROD)

ATTACHMENT C

ODESSA I REMEDIAL ACTION INTERIM REPORT

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6.0 DESCRIPTION OF PROPOSED TREATMENT AND CLOSURE PHASE ACTIVITIES

ATTACHMENT C

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E		Progress Reports
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	E2	Resident Engineer's Progress Reports
	E3	Monthly Progress Meeting Minutes
F		Quality Control/Quality Assurance
	F1	Daily Operations Reports
	F2	Contractor's Daily Quality Control Reports
	F3	Contractor's Chemical Testing Reports
	F4	Contractor's Sludge Testing Reports
	F5	Resident Engineer's Chemical Testing Reports
	F6	Resident Engineer's Non-Chemical Testing Reports
G		Contractor's Requests for Payment
H		As-Built Drawings
I		Operation and Maintenance Plan

F:\CL\ODA\TOC

ATTACHMENT C
ODESSA I REMEDIAL ACTION

FINAL REPORT
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1.0 INTRODUCTION

2.0 INTERIM REPORT

3.0 DESCRIPTION OF REMEDIAL ACTIVITIES DURING TREATMENT AND CLOSURE PHASES

- 3.1 Chronology of Major Activities
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- 5.1 Narrative Summary
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- 5.3 Summary of Punchlist and Corrective Action

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7.0 DESCRIPTION OF PROJECT FILES

8.0 LIST OF APPENDICES

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	E3	Monthly Progress Meeting Minutes
	E4	Monthly Well Reports
F		Quality Control/Quality Assurance
	F1	Daily Operations Reports
	F2	Contractor's Daily Quality Control Reports
	F3	Contractor's Chemical Testing Reports
	F4	Contractor's Sludge Testing Reports
	F5	Resident Engineer's Chemical Testing Reports
	F6	Resident Engineer's Non-Chemical Testing Reports
G		Contractor's Requests for Payment
H		As-Built Drawings
I		Operation and Maintenance Plan

WEDZEB ENTERPRISES REMEDIAL ACTION: PLANNING FOR AN EFFICIENT REMEDIAL ACTION COMPLETION

(Author(s) and Address(es) at end of paper)

INTRODUCTION

The Superfund program was initiated with the promulgation of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980. Through the early stages of the Superfund program, the primary focus of the program was completing remedial investigations(RI)/feasibility studies (FS). Near the end of the 1980s and in the early 1990s, the Superfund program shifted emphasis from RI/FS activities to remedial design/remedial action (RD/RA) activities. As the Superfund program shifted its emphasis to the RD/RA phase, effective planning and implementing of remedial construction activities utilizing a phased approach was imperative. This was especially true for complex sites requiring multi-media remedial actions of several contaminated media. Utilizing a phased approach to RD/RA projects is essential for the following reasons:

- It ensures that Statements of Work for both fund-financed and potentially responsible party (PRP)-lead are drafted to allow for flexibility in the project implementation schedule during the RD/RA phase.

- It demonstrates to the public that the U.S. Environmental Protection Agency (USEPA) is progressing with remedial actions at National Priority List (NPL) superfund sites.

- It provides the EPA with a mechanism to demonstrate to the public that narrowly defined objectives of the Superfund Program, namely RA start and RA completion, are being attained.

This paper will demonstrate how a cost-effective phased approach to an NPL Superfund site RA was implemented at the Wedzeb Enterprises site in Lebanon, Indiana.

BACKGROUND

At the Wedzeb Enterprises site, a fire which completely destroyed a warehouse containing numerous capacitors and transformers containing PCBs. Although a removal action was completed to remove the debris generated by the fire, the Phase I RI analytical results (USEPA, 1989a) indicated that additional surface soil and sediment remediation was necessary. The Record of Decision (ROD) and the associated Explanation of Significant Differences (ESD) specified that the RA must involve cleaning and testing approximately six hundred feet of sewer line, excavating approximately fifteen cubic yards of low-level PCB-contaminated surface soil, and offsite disposal of sewer sediment, excavated soil, and RI-derived waste (USEPA, 1989b). A phased approach to the RA was chosen.

Sanitary Sewer Activities

An RA contractor cleaned approximately six hundred feet of sanitary sewer pipe over a three-day period in April 1990 (USEPA, 1990). The cleaning was accomplished by hydraulically jetting the pipe, then suctioning the liquid and sediment with a vacuum pump from a manhole to a temporary reservoir tank. From the temporary reservoir tank, the liquid containing the sediment was pumped through a bag filter and a carbon adsorption unit to remove organic contaminants. The liquid was finally metered to a carbon-steel holding tank, where samples were collected to determine contaminant concentrations.

The hydraulic jetting consisted of running a hose with a jet nozzle attachment through the 600-foot segment of sanitary sewer pipe, scouring the pipe walls with high-pressure water. Standard sewer plugs were used at both manholes to block the flow of jetted water downstream and to temporarily prevent the flow of wastewater into the adjacent segment which did not require cleaning. Once the plugs were installed, the pipe line was jetted using a variety of nozzles that spray along the pipe walls at various angles. The sediment and grit deposited in and on the pipe was flushed to the downstream manhole. Once the jetted water and loosened sediment were collected in the downstream manhole, a vacuum truck with a submersible hose pumped out the manhole. The fluids from the manhole were then pumped to a temporary reservoir for storage and settling of solids from the fluids. From the temporary reservoir, the fluids were sent through the bag filter to separate the solids from the liquids, retaining the solids within the unit.

After passing through the bag filter, the liquid was then sent through carbon adsorption units to remove the volatile organic compounds and PCBs. The carbon adsorption units removed the organic contaminants in the water, including PCBs that the bag filter had not removed. After filtration was complete, the carbon was containerized and later composited with existing RI-derived waste during the RI-derived waste disposal activities, which were completed in August 1990.

A tanker truck was used to contain the water as it was discharged from the carbon adsorption units. The tank's 5,000-gallon capacity was sufficient to contain the liquid generated from the jetting and pumping operations.

Disposal of the generated wastewater from the tanker and sewer sediment was the final procedure in the remediation process. A liquid sample collected from the 5,000-gallon tanker and a sediment sample collected from the bag filter

were analyzed to determine the magnitude of PCB contamination. The analytical results from the liquid and sediment samples indicated no PCB contamination. Therefore, the wastewater was discharged to the sanitary sewer. The sediment was containerized and later composited with existing RI-derived waste during RI-derived waste disposal activities.

After the sanitary sewer had been cleaned and the wastewater had been removed, the pipe was inspected. This television inspection consisted of a skid-mounted, closed-circuit camera that sent signals to an aboveground monitor. The camera was guided through the pipe by a winch and pulley system, and the monitor was located in an onsite vehicle. Operation of this apparatus consisted of pulling the camera skid between two manholes. A tag line attached to the rear of the camera allowed the operator to back up the camera. A footage meter kept track of the distance traveled so that any problem could be readily located. The inspection was videotaped to provide a permanent record of the inspection.

The results of the television inspection indicated that the sewer was structurally sound and clean from contamination. A videotape of the inspection was recorded and put in the project file.

Soil Excavation and Disposal Activities

An RA contractor excavated and removed approximately fifteen yards of surface soil to a depth of 3 to 6 inches along the southern and eastern part of the site. The location and depth of removed soils were based on the August and December 1989 Indiana Department of Environmental Management (IDEM) analytical sampling results.

During the soil excavation, 30 drums containing wastes generated during the RI and the sanitary sewer RA were composited with the excavated soils. These composited soils were sampled and analyzed in May 1990 to determine their PCB concentrations. The sample analytical results indicated less than 15 ppm PCBs. Based on these analytical results, the excavated soil was composited with the RI-derived waste, and a total of 20 yards of material was transported to the Prairie View sanitary landfill, for more cost-effective disposal. This excavation and disposal was completed in three days.

In addition, 30 drums were emptied and crushed onsite. Because they had not been used to containerize any wastes, these nonhazardous crushed drums were sold to a scrap-metal distributor.

DISCUSSION

Based on the relatively low cost of the remediation ($75,000) and the fact that two different contractors could perform the RA, the implementation of the RA was conducted using the following phased approach:

- The contractor was asked to utilize the small-purchase procedures established in Part 13 of the Federal Acquisition Regulations (FAR).
- The RA was conducted in two stages: sanitary sewer cleaning and soil excavation and disposal.
- The RA Report was structured similarly to the close-out report.

Generally, Superfund RA contracts require use of the sealed bidding solicitation process for contracts greater than $25,000 established in Part 14 of the FAR. Sealed bid solicitation is a lengthy process that usually requires a minimum of 15 months. Initially, invitations to bid are prepared. The bid package and bid review period are published in the local newspapers and trade journals. After bids have been received, the bids are tabulated, evaluated, and awarded to the lowest bidder. The award of the RA contract is also published.

For the Wedzeb Enterprise site, the USEPA realized that the proposed RA described in the ROD and ESD could be divided into separate tasks and completed separately. The RA was separated into the cleaning of the sanitary sewer and the soil excavation and disposal. By separating the RA into two tasks, the cost of the RA could also be separated. The cost of cleaning the sanitary sewer and the soil excavation and disposal were estimated to be less than $25,000 each. Therefore, the small-purchase procedures established in Part 13 of the FAR could be utilized.

The small-purchase procedures in Part 13 of the FARs enable the USEPA to acquire a minimum of three bids directly from RA contractors. Using the small-purchase procedures enabled the RA to be completed under budget and only 15 months after signature of the ROD. The RA tasks also could be scheduled more efficiently and the contractor was able to mobilize quickly to the site, which helped to demonstrate to the public that the USEPA was progressing with the RA.

The RA was conducted in two stages including sanitary sewer cleaning and soil excavation and disposal. It was realized that by separating the RA, each task could be scheduled more efficiently. By scheduling more efficiently, the contractor

was able to commence work in the field more quickly. At the beginning of each phase of work, a public meeting was held to inform the community of the commencement of the RA. By holding these public meetings, the USEPA was able to demonstrate quite effectively to the public that the RA at Wedzeb Enterprises site was timely and appropriate. At the end of the second phase, the USEPA was easily able to demonstrate to the community that the narrowly defined goals, RA start and RA completion, were attained.

By structuring the remedial action report to be similar to the close-out report, each report could be prepared simultaneously, and the deletion process could begin immediately. The early start on the close-out report allowed the Wedzeb Enterprises site to be deleted from the NPL more quickly. This timely deletion also helped demonstrate to the public that the USEPA was accomplishing the RA start and RA completion.

CONCLUSIONS

By implementing a phased approach at the Wedzeb Enterprises, the RA was completed under budget and only 15 months after signature of the ROD. If the contracts had been obtained through the bidding process, it is unlikely that the project could have been completed in 15 months. The phased approach also provided for the proper scheduling of activities for the RA to be efficiently completed. Finally, the similarity between the remedial action report and the close-out report allowed both reports to be completed simultaneously. The result was RA completion and initiation of the deletion process in a short time.

Although the Wedzeb Enterprises site was relatively small, this approach would apply to larger, more complex sites. This would be true particularly if the RA had multiple components. Many times, these components are totally independent of one another. The more straightforward components can and should move forward while the treatability study stage is underway for other areas of the site.

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The Lansdowne Radiation Site; Successful Cleanup In A Residential Setting

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INTRODUCTION

During the early 1900s, the radionuclide Radium 226 was utilized in medicine and for industrial purposes with few or no precautions taken in regard to radiological health. Production, purification and packaging of this radionuclide was conducted at small industrial sites, laboratories, and even private homes.

In 1910, Dr. Dicran Kabakjian, a professor of physics at the University of Pennsylvania, developed a process for the purification of radium. This process was used by a local company that employed Dr. Kabakjian as a consultant from 1913 to 1922 when the company closed down. Two years later, the professor opened what was essentially a family-run business in his house at 105 east Stratford Avenue in Lansdowne, Pennsylvania. He continued to produce and repair radium implant needles used by physicians in the treatment of cancer, and to work with other medical devices for twenty years. Dr. Kabakjian died at the age of 70 in 1945. He had suffered from emphysema and a fibrous tissue buildup in his lungs, possibly due to his breathing of acid fumes from his radium extraction process.

In 1949, 105 E. Stratford Avenue (the Kabakjian side of the twin house) was sold to the Tallant family, who, in turn, sold it to the Kizirian family in 1961.

In 1963, based on information gathered from private individuals, the Pennsylvania Department of Health inspected the house and found extremely high levels of radiation which prompted state officials to begin to look for a way to clean up the property. Unable to address the problem and cleanup through state or federal regulations, the Department of Health ordered the Kizirians to decontaminate their home. The Kizirian family enlisted the assistance of a local congressman and eventually the U.S. Public Health Service and the Pennsylvania Department of Health decontaminated the 105 E. Stratford portion of the twin house as a "demonstration" project in 1964. The U.S. Air Force also contributed to the decontamination effort by supplying a mobile radiation laboratory to monitor the cleanup.

The 1964 decontamination effort consisted of removing as much radium as practical by sanding, scraping, vacuuming, and washing the house walls, floors and ceilings. Some wooden floorboards and portions of the concrete basement floor were also removed. It is postulated that the acid fumes from the radium- purification procedure which Dr. Kabakjian used, as well as spills, burning of contaminated newspapers, and "tracking" of the radium on the bottoms of the residents' shoes carried the radium throughout the home and resulted in its penetration deep into the wood and plaster of the house. After the cleanup, the house received epoxy-based paint coatings to limit the outward migration of the remaining radium. It is estimated that approximately 90% of the radium in the house was removed in the 1964 cleanup action.

In the summer of 1964, the Kizirian family was allowed to move back into 105 E. Stratford. The U.S. Public Health Service estimated that, based on a 16 hour-per-day exposure, the radiation

dose rate received by the occupants was just above the then existing guideline of 0.5 rem/yr, and that further decontamination of the house would be impractical. The Kizirian family continued to live in the house.

Just on the other side of the common wall of the twin house, at 107 E. Stratford Avenue, the Bashore family lived in the home that they had occupied since 1919, the same year that the Kabakjians had moved into 105. No action was taken at 107 in 1964 when the contamination in 105 was addressed.

DISCUSSION

In 1983, EPA was requesting information from all states concerning radioactive sites that might be eligible for Superfund cleanup monies. The Pennsylvania Department of Environmental Resources (PADER) notified EPA of the Lansdowne site and its previous contamination. In early 1984, EPA and PADER sampling and monitoring of the structure showed high radon and gamma radiation levels in 105 (the Kizirians) and high radon levels but with lower gamma levels in 107 (the Bashores). Additionally, very high levels of radiation were measured in the soil around the properties. In March, 1984, the Chronic Disease Division of the Centers for Disease Control (CDC) wrote that based on the measured levels, "...the entire duplex structure should be considered to pose a significant health risk to longterm occupants." Gamma radiation levels were found to be about 100 micro-Roentgens per hour (uR/hr) throughout most of 105 E. Stratford, and ranged to 300 uR/hr in the dining room. Radon daughters were measured using an EPA RPISU and found to be about 0.3 Working Levels (WL). (It should be noted that this was before the discovery of the infamous Watras House in the Reading Prong area of Pennsylvania and that the radon levels in the Lansdowne home were thought to be very high at the time.)

A simplified gamma dose calculation for 100 uR/hr yields in excess of 800 mrem per year, so, assuming average exposures, the residents were exceeding acceptable gamma exposure limits for the general public. An exact dose prediction accounting for gamma energies, etc. was not performed because the actual exposures of the residents was also dependent on the time spent in various places in the house. This could not be determined with any accuracy. It was also clear that the radon decay product exposure would be about 15 Working Level Months (WLM) per year. This computation was based on a 50 WLM per WL exposure, and is reasonably accurate assuming occupancy by pre-school children who would spend the majority of their time in the house. This exceeds the 4 WLM per year occupational standard for uranium miners. In September, 1984, EPA, in coordination with the Federal Emergency Management Agency (FEMA) began a temporary relocation effort for the residents of the twin house. These actions were taken as part of a larger effort to determine and to minimize the threat to the local community and the environment. Mrs. Kizirian (105 E. Stratford) was moved to an apartment in the area. Mrs. Bashore (107 E. Stratford) declined the relocation. She was remarried in November, 1984, and moved to the home of her new husband.

EPA's emergency response action in 1984 included the installation of burglar alarm and fire alarm systems, and a full sprinkler system throughout the structure. A 1000-gallon water bladder was installed in the basement of each house as a back-up for the municipal water supply. The insides of all windows were sealed with plastic to minimize radon and radon daughter dispersion, and security arrangements were made with the Lansdowne Police Department.

Some of the furniture in the homes was found to be free of contamination and was removed for the residents' use. Contaminated furniture and other household belongings were left in the houses pending the remedial action. The owner of 107 E. Stratford expressed her desire to save a number of pieces of heirloom mahogany furniture which were found to be contaminated with radium. Initial efforts during the emergency response action failed to satisfactorily decontaminate most of the items.

After the EPA involvement in the site became known, the fears of the site neighbors with regard to the possible contamination of their respective homes had to be addressed. EPA handled this by offering to survey the house of anyone in the neighborhood who asked. The various news media were contacted to help extend this offer to those people who possessed articles which were taken from 105 or 107 E. Stratford Avenue in years past and which might be contaminated with radium. Because of the number of houses involved, the home surveys were conducted using a micro-R meter. This search found that none of the nearby houses had been contaminated. However, the survey showed elevated gamma levels in the back yards of the six adjoining properties. It was not clear at the time whether this was due to shine from the 105/107 property or to contamination which had migrated off the property.

As a result of news media attention, a few contaminated items were found which had previously been removed from the house. The most important of these proved to be three metal cabinets which had been removed from the basement of 105 E. Stratford by Dr. Kabakjian's son, and which had been placed in the basement of that son's home, also in Lansdowne, not far from the E. Stratford Avenue site. These cabinets had resulted in the contamination of the son's home, and required a subsequent emergency response action (called "Son of Lansdowne") by EPA.

As part of the emergency removal action at the 105/107 E. Stratford Avenue site, the sewer lateral from 105, and the street sewer were surveyed. Using a 2 X 2 sodium iodide detector, gamma levels up to about 190 micro-R per hour were detected. The survey process was somewhat complicated by the natural thorium content of the clay used to make the original sewer pipe.

Records of Decision

Following EPA's initial emergency response actions at the site, a Record of Decision (ROD) was signed on August 2, 1985 by the EPA Region III Regional Administrator based on the studies which had been performed on the site by Argonne National Laboratories. This first ROD provided for the permanent relocation of the site residents. However, this matter became a non-issue when the owner of 107 E. Stratford remarried and moved to her husband's home as noted earlier, and the owner of 105 E. Stratford died in early 1986 while occupying the apartment which had been provided under the temporary relocation during the emergency response action. The selected Remedial Alternative, designated in a second ROD dated September 22, 1986, called for the removal of the contaminated structures and the contaminated soil to an approved offsite disposal facility. The ROD also called for the removal and replacement of the contaminated sewer line on E. Stratford Avenue. The ROD provided that, after removal of the contaminated structures and soil, the site would be backfilled with clean soil and revegetated. At the time, the project was expected to cost approximately $4,500,000.

Remedial Design

EPA Region III developed an Interagency Agreement (IAG) with the U.S. Army Corps of Engineers (USACE), Omaha District, to develop specifications for the cleanup and to select a remedial action contractor through a process of evaluating contractor- submitted proposals. Of major concern in the development of the specifications were the protection of area residents from radioactive aerosols, and the level to which contaminated soil would be cleaned up. It was decided that the specifications would only generally require the protection of the residents from radioactive dusts, and that the proposals from the contractors would be evaluated with particular attention to the method that each contractor proposed for providing that protection. EPA also decided, after consultation with USACE and Argonne National Laboratory personnel, that the UMTRACA standard of 5 pico-Curies per gram (pCi/g) above background for surface soil at uranium mill tailing sites was an appropriate cleanup criterion for the soil in this densely-populated area.

It was conservatively estimated at that time of the design process that approximately 1000 tons of contaminated soil would have to be excavated. It was also assumed, for the purposes of the proposals, that the house was of frame and stucco construction, and that approximately one-half of the rubble from the house would be disposed of as contaminated waste while the other half would become ordinary demolition debris. After checking on the potential disposal costs for the weights and volumes of the estimated amounts of contaminated wastes, USACE requested that an additional $1.5 million be added to the project budget. That brought the remedial action budget to $6 million.

On April 26, 1988, USACE, Omaha District awarded the construction contract to Chem-Nuclear Systems, Inc., of Columbia, South Carolina. Oversight of the project was transferred to the USACE Baltimore District Office in May, 1988.

Site Access

It was, of course, necessary to gain access to the several properties which would be involved in the remedial action. To prevent the loss of valuable personal property belonging to the owners of 105 and 107 E. Stratford Avenue, the Commonwealth of Pennsylvania legislated money to pay those owners the values of their properties. Two independent assessments were performed for each residence and by way of contracts among the property owners, EPA, and the Commonwealth of Pennsylvania, the owners were paid the full values of their respective properties. Under the agreements, they would also retain the ownership of the building lots and would take possession of those lots following the remedial action.

Written access statements were obtained from the six property owners surrounding the 105/107 E. Stratford Avenue property because it was suspected that the soil of the back yards of those residences would be contaminated with radium and would require excavation. One home owner was in the process of attempting to sell his house during this process and resisted allowing EPA access to his property. After lengthy and unsuccessful negotiations, EPA requested the assistance of the Department of Justice whose attorney convinced the homeowner that it was in his best interest to grant EPA the necessary access. The other five home owners were more easily persuaded to grant access due in large part to a clause which EPA had incorporated into the USACE Request For Proposal. That clause called for the remedial contractor who would perform the cleanup to replace all fencing, walkways, buildings, trees, shrubbery, etc., damaged or destroyed as part of the cleanup of any "offsite" properties. Access was also gained from a property owner whose driveway was to be blocked during the remediation. That access was for the purpose of constructing a temporary driveway on another portion of her property for her use during the remedial activities.

The Remedial Action

USACE issued a Notice to Proceed to Chem-Nuclear Systems, Inc., on June 1, 1988. After a number of meetings and various preparations, Chem-Nuclear began activities onsite at the beginning of August. These onsite activities included the complete fencing of the 105/107 property, the installation of electric and telephone service, the construction of a small building to separate contaminated from uncontaminated wastes, the placement of 4 trailers to house the site management, the crew, the USACE Project Engineer, and Argonne National Laboratories personnel. The trailers and the building were placed on E. Stratford Avenue thereby blocking the street for nearly one block and preventing the passage of any traffic.

Removal of the structure was accomplished from the inside out. The shell of the house was used as a containment to prevent migration of the radium off the site. The structure was kept at a negative pressure with a fan and HEPA filter to prevent leakage. Material removed from the house was classified as either "rad waste" or as demolition waste. This process required some

simplifying assumptions otherwise the process of separation of the waste would have been prohibitively costly. All materials with inaccessible interior surfaces, porous surfaces, or painted surfaces were classified as rad waste. Materials noticeably above background on a G-M survey meter received similar treatment. Because the background was somewhat elevated, three background counts were used to estimate a standard deviation of the background at the place the meter was to be used. If the reading obtained from an object was more than two sigma above background, it was classified as rad waste. In the end, only two items from the structure, a half brick and three quarters of a brick, were classified as uncontaminated waste. Whereas it had been originally assumed that the houses were of frame and stucco construction, it was discovered during the dismantlement that the exterior walls were of solid stone, ranging from 24 inches thick at the foundation to 18 inches thick at the roofline.

Worker protection on the site consisted of cotton coveralls, booties, and respiratory protection. Two forms of respiratory protection were used: negative pressure HEPA filter respirators and Racal AH-3 Air Stream helmets. The latter devices incorporate helmet protection, eye protection and respiratory protection in a single unit. In these units, a battery powered fan mounted on the wearer's belt blows filtered air across the face. The protection factor is about 30. These devices were recommended by Argonne National Labs personnel because of their favorable experience with the units. The units were considered equivalent to level C protection and were used interchangeably with filter respirators. Higher levels of protection were not used because the site had previously been cleaned of most of the original contamination and because truly dangerous atmospheres could not reasonably be anticipated based on the extensive site survey performed prior to the remedial action.

The site Health Physicist expressed concern about the Racal units because of their need for frequent repairs and their bulkiness, especially when used in close quarters. The advantages of these units include the lack of the need for a tight facial air seal and ease in breathing. Choice of level C protection was judged to be appropriate upon evaluation of the air measurements taken during the interior work. The cumulative average airborne contamination for the entire job was 1.2 Maximum Permissible Concentrations per hour (MPC-hr). This is far below the MPC for radium. The maximum level measured during the remedial action was 7.5 MPC-hr for one two-hour period at one location.

The yard around the house had shown obvious signs of contamination on the initial surveys done during the 1984 emergency response action. Samples taken from "hot spots" showed high radium concentrations in the soil. That initial survey strategy was influenced somewhat by statements made by a next door neighbor that she remembered truckloads of "ore" being dumped in the side yard of the house. The initial survey, however, indicated that the soil contamination was more or less uniformly distributed and had been washed into the soil by rainfall. Soil core samples appeared to confirm this assumption. However, upon excavation during the remedial action, the pattern of contamination was found to be quite different. The hottest spots (1-2 mR/hr gamma) were associated with broken test tubes apparently buried six inches to one foot below the ground. A hot spot was discovered immediately to the right of the front porch door. It appears that the professor occasionally discarded solutions by dumping them on the ground beside the door and even had buried some materials in his yard. Most of the liquid waste from the radium-refining process was probably disposed of in the sewer.

Several areas which, during the emergency response action, had appeared to be contaminated, were found to be free of contamination during the remedial action. Elevated gamma readings in those areas were apparently due to radon decay products which had migrated underground. Since radium itself is only a weak gamma emitter and the 214-Pb and 214-Bi radon decay products are the principle gamma emitters, the gamma surveys showed the location of the radon daughters, not the radium. Radon transport underground was shown to be an important process which will affect the ability of a survey to locate the source of contamination in future radium sites.

Rotted tree roots were uncovered which had apparently acted as conduits for the radium. It is not known whether the trees were alive when this process occurred, or whether the radium followed the channels formed by the rotting roots. Radium levels in the soil near these roots was 14-50 pCi/g.

Soil contamination found during the remedial action was more extensive than had previously been estimated. Radium contamination to a depth of 9 feet was found in the 105/107 E. Stratford backyards and to 11 feet on two adjoining properties. The contamination had migrated onto all six of the adjoining properties and required excavation. Trees, fences, shrubs, and lawns were destroyed in the cleanup process. The sewer on East Stratford Avenue was excavated for disposal. Garages on two of the adjacent properties were dismantled so that contaminated soil around them could be excavated. Because of the extensive overrun for the soil excavations, an additional $4 million was added to the project in January 1989 bringing the budget to $10 million. The project, primarily because of the extensive soil excavations, was costing up to $300,000 per day. By the middle of April 1989, the project funds were nearly depleted and $1.6 million was added to bring the budget to $11.6 million where it currently stands.

CONCLUSION

In all, 1,430 tons of radioactive rubble (46,698 cu. ft.) and 4,109 tons (83,226 cu ft.) of radium contaminated soil were generated. Prior to remediation of the site, radium levels in the soil ranged as high as 700 pCi/g. Following remediation, radium levels in the soil had been reduced to no greater than 5 pCi/g above the local background of 1.5-2.1 pCi/g. An activity of no greater than 5 pCi/g above the local background qualifies the site by EPA standards to be released for unrestricted use. The total annual radiation effective dose equivalent received by a member of the population in the United States from various sources of natural radiation exposure is estimated to be 300 milli-rems (mrem). The Argonne National Laboratory has calculated the annual dose equivalent on the site after backfilling to be about 75 mrem.

At the end of the cleanup, the site was brought to near- original grades and restored as a grassed lot. A new sewer line was constructed to replace the 243 feet of contaminated line that was removed. Trees on properties adjacent to the 105-107 lot that had to be removed during soil excavation were replaced with nursery stock. A contaminated garage that was removed on the 112 East Stewart Avenue property (at the rear of the 105/107 E. Stratford property) was replaced in kind, as was another non-contaminated garage at 110 E. Stewart that had to be demolished because it was built over contaminated soil.

The project was brought to a successful conclusion without project personnel receiving any radiation dose above the allowable limit and without the release of any radioactive contamination into the environment. EPA is currently pursuing the process which will result in deletion of the site from the National Priorities List.

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Remedial Design Approach and Design Investigations at the Bayou Bonfouca Superfund Site

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INTRODUCTION

This paper provides an overview of remedial design approaches and design investigations for the Bayou Bonfouca Source Control operable unit (OU). General topic areas include:

- Background site history and remedial investigations
- General remedial design approach and design investigations
- Pilot Study dredging and material handling
- Bayou sediment dewatering
- Air emission flux testing
- Air emission dispersion modeling

BACKGROUND

The Bayou Bonfouca site (Figure 1) is located in Slidell, Louisiana, in St. Tammany Parish. The site is approximately 25 miles north and east of New Orleans. The site's name is a reference to Bayou Bonfouca, which forms the southern boundary of the site. Bayou Bonfouca is a tributary of Lake Pontchartrain, approximately 7 miles to the south of the site. The site encompasses approximately 55 acres.

Land east of the site is primarily used for commercial purposes. Land north and west is generally residential, and land to the southwest across Bayou Bonfouca is a residential subdivision. About 750 people live within 1 mile of the site. Bayou Bonfouca is used for industrial activities downstream of the site, and recreational boating upstream and downstream. The majority of the site lies within the 100-year flood plain of the bayou.

The bayou has been dredged downstream of the site. In addition, a turning basin has been dredged adjacent to the site that is used for barge operations. It appears that the turning basin was constructed by excavating into the bayou bank at the southern boundary of the site and erecting a bulkhead along a 250-foot length of this boundary. The turning basin is approximately 250 feet wide and 10 feet deep. Upstream, the bayou is considerably shallower and narrower.

SITE CONTAMINATION HISTORY

The earliest records of the Bayou Bonfouca site date back to 1892 when a creosote wood-treating facility was reportedly developed onsite. The creosote plant treated pilings for use in the construction of a railway across Lake Pontchartrain. Over the years, the plant operated under the ownership of various creosote companies. During the operating history of the plant, there were apparently numerous releases of creosote onto the site and eventually into the bayou. In 1970, the plant burned and, reportedly, a large amount of creosote was released from storage tanks onto the site and into Bayou Bonfouca.

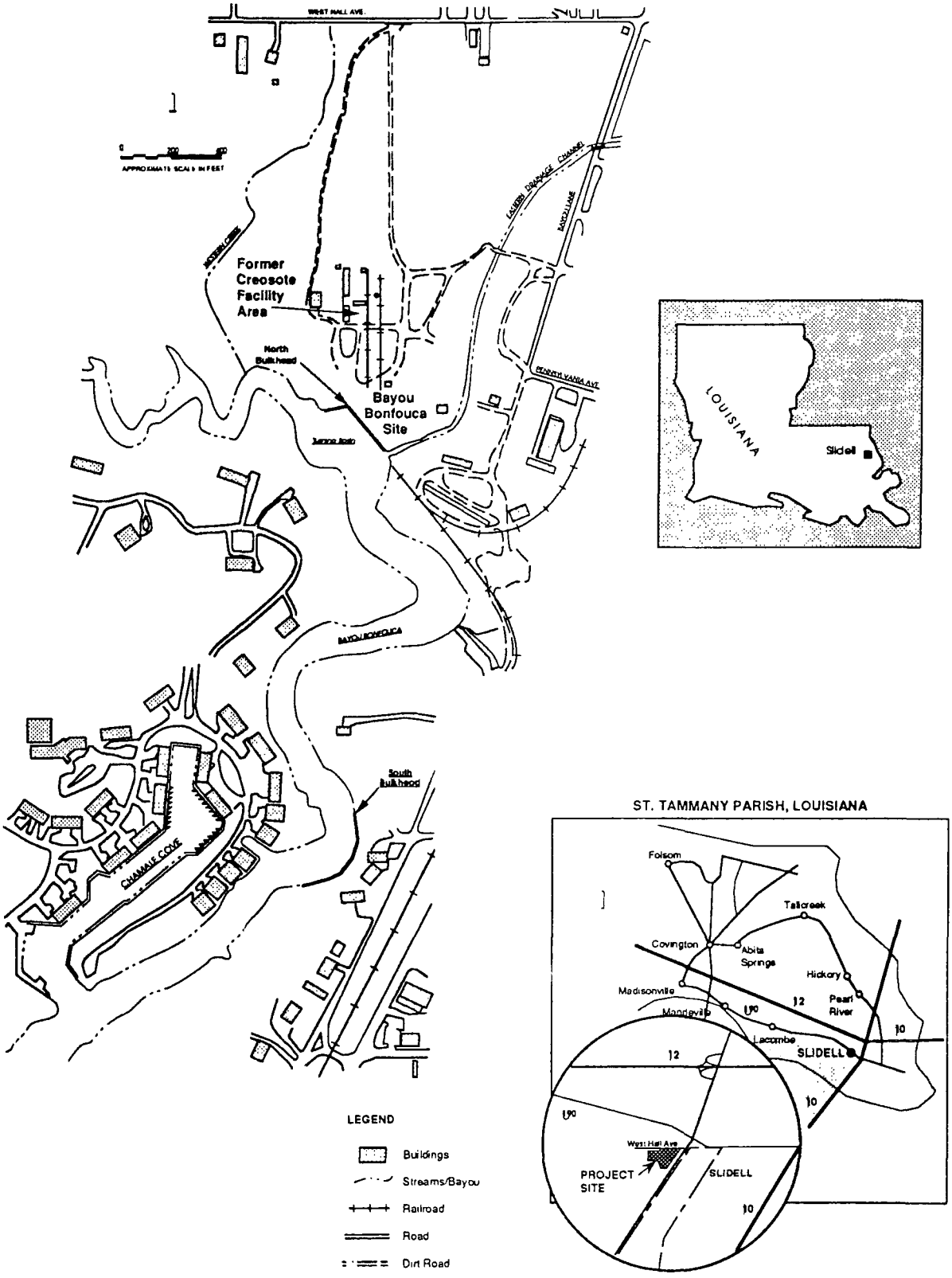

Figure 1
Bayou Bonfouca Site
Slidell, Louisiana

Available records indicate that creosote was the only preservative used at the site. Creosote, distilled from bituminous coal, is a complex mixture of over 400 individual components. Polynuclear aromatic hydrocarbons (PNAs or PAHs) comprise over 90 percent of the creosote components. Based on previous investigation data, PNAs have been chosen as the indicator parameter(s) for Bayou Bonfouca site contamination.

REMEDIAL INVESTIGATION ACTIVITIES

In April 1976, the U.S. Coast Guard began investigating the pollution of Bayou Bonfouca. The investigation revealed that creosote was discharging overland via runoff into the bayou and that boats had been damaged from contact with oily substances in the bayou. A followup sampling program conducted by the U.S. Environmental Protection Agency (EPA), the U.S. Coast Guard, and the National Oceanic and Atmospheric Administration (NOAA) in 1978 characterized the contaminants as containing numerous aromatic compounds. The heavier fractions of these compounds were reported to be in sediments within 400 to 500 yards of the plant site.

From 1979 to 1980, the regional response team began evaluating alternate methods to address site problems. Several options were evaluated; however, no action was taken because it was felt that removal of the contaminated bayou sediments required further study.

From 1980 through 1982, several investigations were performed onsite for the U.S. Coast Guard and the NOAA. These studies included qualitative evaluations of the components of the contaminated sediments, analysis of organisms from the bayou, and estimates for surface waste volumes.

In December 1982, EPA included the Bayou Bonfouca site on the National Priorities List (NPL) for Superfund sites. Remedial investigations (RIs) were performed by EPA from late 1983 through early 1986. The RIs investigated the extent of creosote waste and contamination in onsite waste piles, onsite soils, onsite and offsite groundwater, and bayou sediments.

FEASIBILITY STUDY/RECORD OF DECISION

A feasibility study (FS) for the Bayou Bonfouca site was completed in 1986. The FS presented and evaluated a range of alternatives for remediating the threats posed by site contaminants.

In March 1987, the EPA selected a remedial alternative to mitigate the threats posed by hazardous waste at the Bayou Bonfouca site. The selected remedy was presented in the Bayou Bonfouca Record of Decision (ROD) under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). In 1989, EPA decided to separate the remedial action and associated design activities into two operable units (OU), the

Groundwater OU and the Source Control OU. The original ROD was amended in February 1990 in a document entitled *Explanation of Significant Differences* to reflect changes to the remedy based on the more than threefold increase in the estimated volume of contaminated bayou sediments that resulted from the 1988 sediment investigation data.

As defined by the amended ROD, the scope of remedial activities to be performed under the Source Control OU includes the following:

- Contaminated sediment in Bayou Bonfouca, the eastern drainage channel, the western creek, and contaminated waste piles will be incinerated onsite.

- Dredging will be conducted to "safe slopes," which will result in minor amounts of contamination being left in place in some areas. In areas where dredging to achieve stable slopes would result in leaving significant volumes of contaminants, bulkheads will be placed and the material removed.

- During dredging operations, turbidity or silt curtains and absorbent booms will be placed along the bayou, at the ends of the bayou, and surrounding the operations, to aid in controlling the release of contaminants during dredging.

- Dredged areas will be backfilled with clean material to provide a barrier against contact.

- Residual ash and contaminated soils to be consolidated will be disposed in the onsite landfill. The landfill will be covered with a RCRA-compliant cap.

- Contaminated onsite soils outside of the landfill area between 100 and 1,000 ppm total PNAs will be consolidated within the landfill. Contaminated soils greater than 1,000 ppm total PNAs will be incinerated.

DESIGN ACTIVITIES

Design of the remedial action was initiated in June 1987. One of the first activities was to develop the design basis for the project. Design basis development included the collection and evaluation of data to provide the technical input for the remedial design activities. The previous site data base, compiled during remedial investigations, identified the nature and extent of contamination and provided a foundation for the FS. This site data base needed to be expanded to provide remedy-specific data necessary for design and subsequent remedial construction. To obtain this data, design investigations were performed as part of the Bayou Bonfouca remedial design.

Design investigations were conducted from May 1988 through June 1990. Investigations were performed for the following purposes:

- To better determine the degree of sediment contamination in the bayou
- To investigate the extent of groundwater contamination beneath and adjacent to the site
- To assess the geotechnical characteristics of subsurface materials at the site for design of the onsite landfill and related facilities
- To provide a general characterization of wastes at the site
- To assess dewaterability and material handling properties of contaminated bayou sediment
- To investigate air contaminant emission rates from potential waste handling and process operations
- To determine slope conditions along the bayou banks that may be affected by dredging

The design of the Groundwater OU was completed in June 1989 and construction was awarded in October 1989.

The Source Control OU design was completed in September 1990. A solicitation for Source Control OU remedial action proposals was conducted and contractor proposals were received through March 4, 1991. The proposals are currently under evaluation by the U.S. Army Corps of Engineers (USCOE). A remedial contractor selection is anticipated in summer 1991.

DISCUSSION

DESIGN APPROACH

The Bayou Bonfouca Source Control OU final design documents consist of primarily performance-type specifications. This specific design approach was initially developed in mid-1988 under a preliminary design concepts task. The main reasons for selecting the primarily performance-specified design approach were:

- Multiple technologies and approaches are available for use in the site remediation. Performance specifications allow for contractor flexibility in using familiar technologies and methods. This allows for maximum remedial action bid competition.

- The majority of the remedial action work is service-oriented and involves the use of temporary facilities for which EPA and Louisiana Department of Environmental Quality (LDEQ) would not assume long-term responsibility.

The Bayou Bonfouca design investigations were conducted to support the design effort. The investigation costs were considered versus potential benefits of additional site-specific information. The primary benefits identified for additional site information included:

- Significantly improved data for developing representative site remediation design scenarios and costs
- Additional basis for development of specifications
- Significantly improved data to represent the site for vendor bidding considerations

Table 1 lists major remedial action components for the Bayou Bonfouca Source Control OU, and describes corresponding general remedial design approaches and key design investigation input.

The Bayou Bonfouca design investigations encompassed dozens of physical characterization, chemical characterization, and treatability testing programs for various waste areas at the site. The following subsections provide a general perspective on the Bayou Bonfouca remedial design investigations and on use of the resulting data in the design. Focused discussions are also included for the following specific design investigation areas:

- Field dredging and material handling
- Bayou sediment dewatering
- Air emission flux testing
- Air dispersion modelling

PILOT STUDY DREDGING AND MATERIAL HANDLING

Pilot Study dredging and material handling studies were performed to obtain information on oversize material in the bayou, to characterize sediments removed by full-scale dredging techniques, and to provide sufficient sediment quantities for the Pilot Study testing.

During the November/December 1989 Pilot Study conducted at the Bayou Bonfouca site, bayou sediments were dredged, handled in bulk, size classified, and placed into drums. The drummed sediments were used in a range of characterization and treatability tests performed in the field and in subsequent laboratory tests.

Figure 2 shows a schematic layout for the actual Pilot Study operations. The following items highlight the dredging and material handling operations:

Table 1
Summary of Remedial Design Approach/Design Investigation Input

Remedial Action Component	Remedial Design Approach	Key Design Investigation Input
Dredging	Performance specification with section specific dredge lines.	Sediment investigation provided data to define dredge sections for inclusion in construction drawings.
Material handling	Performance specification.	Pilot Study dredging with crane-mounted clamshell revealed numerous logs and poles near the bulkhead. Pilot Study dredged materials were processed, using a double deck power screen, into three size fractions.
Sediment dewatering	No specific performance requirements; contractor systems must conform with applicable regulations.	Lab scale and small field scale dewatering tests provided an idea of probable range for mechanical dewatering of bayou sediments.
Incineration	Performance specification. Sediment incineration payment approach is based on tons of dry ash.	Sediment cores were tested for Btu, ash, and moisture content. This data helped define inputs for incinerator throughput modelling.
Water treatment	Performance specification with a prescribed minimum unit process train: flow equalization, clarification, multimedia filtration, oleophilic media filtration, granular activated carbon, and post-aeration.	Wastewater samples were synthesized using sediments from sediment investigation, and characterized. A 50-gpm pilot wastewater treatment system was operated for the Groundwater OU. This system included oil/water separation, oleophilic media filtration, sand filtration, and granular activated carbon.
Air emissions monitoring and controls	Performance specification. Remedial contractor required to identify air emission sources and fluxes and to perform dispersion modelling.	Pilot Study air contaminant flux testing provided a range of organic fluxes to use as inputs for individual source and combined source dispersion modelling.
Site civil activities		
• Site preparation (waste consolidation, waste excavation, site grading, initial landfill construction)	Detailed design.	
• Landfill operation	Detailed design.	
• Landfill closure	Detailed design.	
• Temporary site facilities	Performance specification.	Geotechnical explorations provided information for evaluating soil load bearing of various site areas for anticipated remedial construction.

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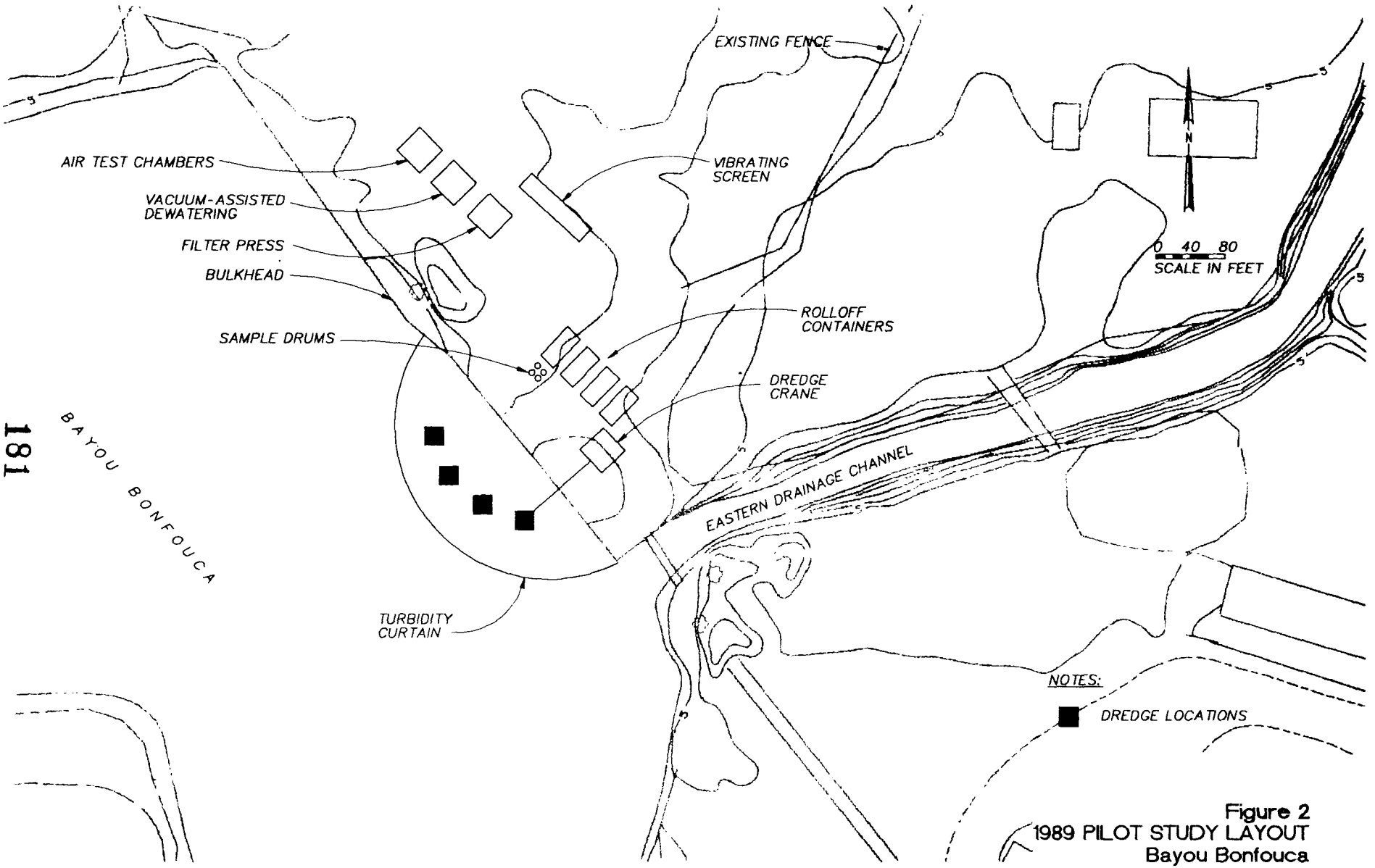


Figure 2
1989 PILOT STUDY LAYOUT
Bayou Bonfouca
Slidell, Louisiana

1=100.0

- Dredging was performed in the turning basin immediately offshore from the bulkhead. The dredging operation was performed within a 350-foot semicircular arc formed by a solid vertical PVC turbidity curtain and bordered by the bulkhead and nearby shorelines.

- Approximately 12 cubic yards of bayou sediments were dredged with a 2-cubic-yard clamshell bucket. Samples of the dredged sediments typically contained 32 to 37 percent solids.

- Dredged sediments were placed in rolloff containers, removed by a backhoe, and fed to a double deck vibrating screen. The sediments were discharged to drums after separation into three size classifications.

- Large tree limbs or logs were encountered in each of the eight clamshell bites. Many oversized objects were "felt" by the crane operator. Several large logs and limbs were pulled up above the water surface during the dredging operations. Some of these were removed and placed onshore, and some fell back into the Bayou. The retrieved oversized tree limbs and logs were cut using a chainsaw and placed into drums.

Figure 3 provides a schematic for the double deck vibrating screen and shows the size cuts for the classified dredge materials. Table 2 summarizes the field measured mass and volume distributions for the three dredged material size classifications.

Table 2

Material Size Classification	Mass %	Volume %
Less than 1/2 inch	70	61
Between 1/2 inch and 2 inches	20	23
Over 2 inches*	10	15

*Does not include trees and poles.

BAYOU SEDIMENT DEWATERING

The Bayou Bonfouca remedial action is centered around incineration. There is significant cost associated with the energy requirements for vaporizing water in the incinerator. Water is contained as an integral part of the as-dredged bayou sediment. The design investigation data showed that the in-place sediments average 51 percent water content on a mass basis. This sediment makes up the majority of the material to be fed to the incinerator. Therefore, the balance between dewatering and incineration costs is an important consideration for the remedial design.

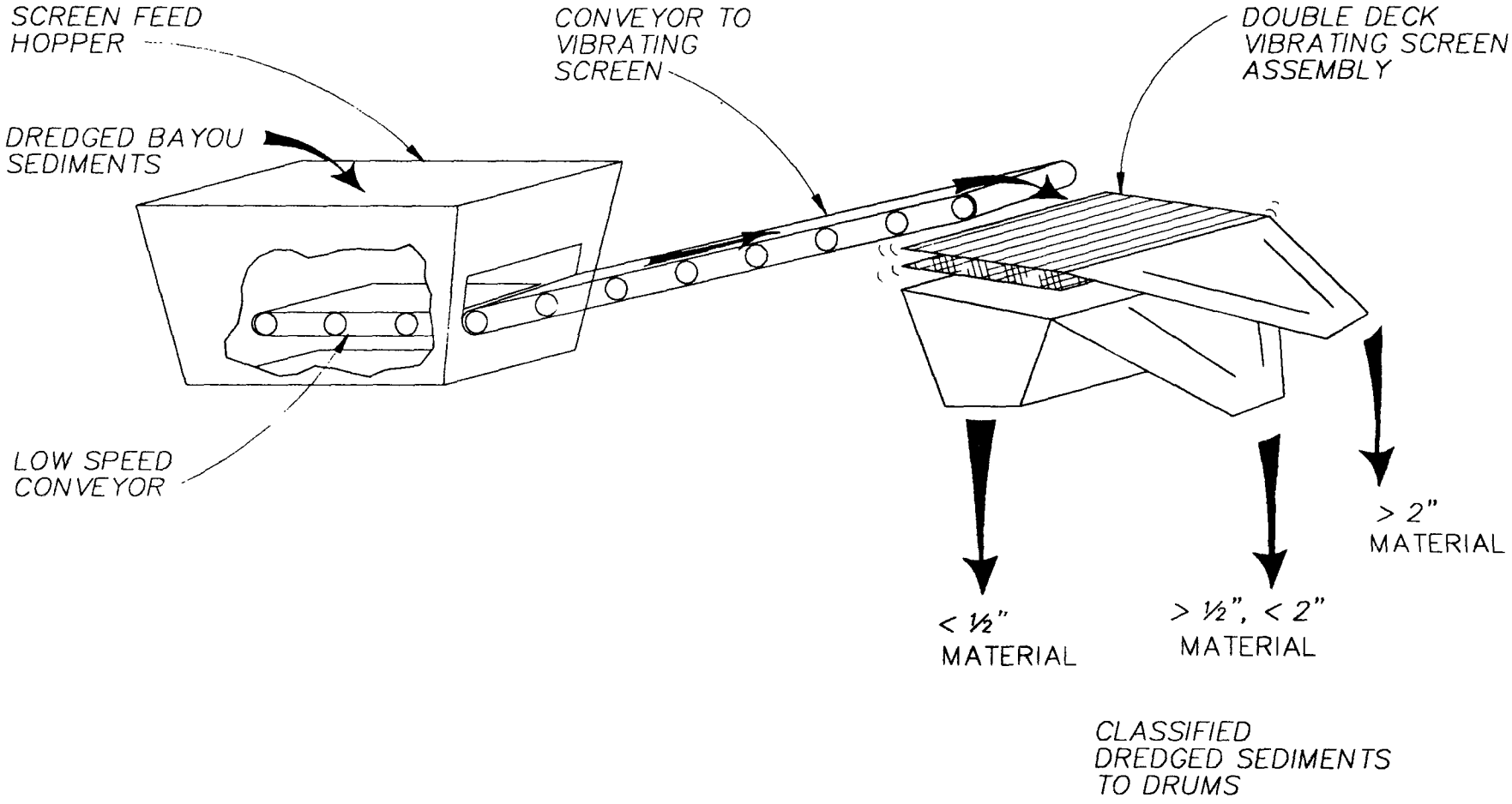


Figure 3
VIBRATING SCREEN SCHEMATIC
Bayou Bonfouca
Slidell, Louisiana

Equipment and Procedures

Dewatering studies have been performed to indicate viable dewatering methods for reducing the water content of the dredged sediment. This experimentation has been performed in three phases: during the initial design investigation, during the pilot study, and following the pilot study at an offsite testing laboratory. During the design investigation of 1988, dredged sediment was not available, so drainage channel sediment, vibracore samples, and bayou water were used to prepare a synthesized sediment sample for settling and dewatering tests. Portions of the synthesized sample were tested using the following methods over a range of dilutions:

- Polymer jar tests (using vendor-supplied products and technical assistance)
- Batch flux curve settling tests (using graduated cylinders)
- Gravity settling tests (using 6-inch-diameter by 8-foot-tall column)
- Capillary suction time tests
- Buchner funnel tests (lab-scale vacuum filtration)
- Sludge drainage tests (bench-scale sand bed simulation)
- Pressure filter tests (using bench-scale device)
- Filter leaf tests (using lab-scale apparatus)

Pilot study testing was performed in 1989 on sludge dredged from near the bulkhead on the southern border of the site, using a clamshell dredge. It was believed that these dredged samples were more representative than synthesized samples tested in the 1988 Design Investigations, yet not necessarily representative of the entire area to be dredged during remediation. The following tests were performed on the dredged samples over a range of dilutions:

- Gravity settling tests (using 6-inch-diameter by 8-foot-tall column)
- Capillary suction time tests
- Filter-leaf tests (using lab-scale apparatus)
- Sludge drainage test (bench-scale sand bed simulation)
- Filter press tests (1 ft^3 pilot unit)
- Lab-scale vacuum-assisted sludge dewatering bed polymer dose testing
- Pilot-scale (8 ft^3) vacuum-assisted sludge dewatering bed tests
- Lab-scale (400-ml) vacuum-assisted sludge dewatering bed tests

A portion of dredged sample was transported offsite to a testing laboratory. Shortly after the pilot study, the laboratory performed the following lab-scale tests:

- Basket centrifugation
- Solid-bowl centrifugation
- Vacuum filtration

- Pressure filtration
- Simulated trommel screen dewatering

Results

Table 3 presents the results of the settling and dewatering testing performed.

The pilot study as-dredged material was typically from 32 to 37 percent solids. The range of dewatering processes tested indicated that solids concentrations of up to 50 percent were possible using sludge drainage, vacuum filtration, and centrifugation techniques. Many of these techniques employed polymers or other additives to reach the higher solids concentrations.

This dewatering testing has provided information that can be applied to numerous remedial design scenarios for the Bayou Bonfouca site. Testing dilute sludges has provided information on the dewaterability of hydraulically dredged sediment, while the more concentrated samples have provided results that describe the dewaterability of the mechanically dredged sediment or thickened hydraulically dredged sediment streams. Information on polymer and additive dosing has also been collected for certain process options over a range of feed concentrations.

AIR CONTAMINANT EMISSION FLUX TESTING

Preliminary flux values were calculated for air contaminant dispersion modelling efforts in the 1988 design investigation phase. These values had been calculated using TSDF, based on the simplifying assumption that the composition of the emission from contaminated soils and other material was 100 percent naphthalene. Since air emissions resulting from the remediation efforts are a major concern at the Bayou Bonfouca site, it was recognized during the planning of the Pilot Study phase of predesign work that more accurate measurements of the magnitude and estimates of the composition of air emissions resulting from anticipated remedial operations were necessary.

Equipment and Procedures

To define a list of target compounds in bayou sediment emissions, a sample of sediment was obtained prior to air emissions field work and was sent to an offsite laboratory for gas chromatography/mass spectroscopy (GC/MS) analysis. The results of this characterization were used to identify target compounds and plan appropriate analytical techniques for use in the field pilot testing effort.

Early in the Pilot Study planning activities, plans were made to fabricate air contaminant flux chambers to obtain contaminant flux

Table 3
Comparison of Dewatering Results from 1988 Design Investigation, Pilot Study, and Offsite Laboratory Activities

	Ranges of Solids Concentration Achieved by Various Dewatering Methods for Each Investigation (percent by weight)		
	1988 Design Investigations	**Pilot Study**	**Offsite Laboratory**
Polymer Jar Test	17.2-22.0	NP	NP
Batch Flux Settling Test	(4.6-10) 14.7-22.6	NP	NP
Gravity Settling Test	(4.6-10.7) 16.7-19.3	(4.7-15.2) 14.4-26.2	
Buchner Funnel Test (vacuum filtration)	(14.2-22.6) 46.4-53.2	NP	(26.5) 37-39
Filter Leaf Test	43-47	(5-20) 33.2-42.7	NP
Sludge Drainage Test (sand bed simulation)	(17.5) 42.3-50.7	(16.9) 31.0-49.2	(10-30) 23-30
Pressure Filter Test	*	NP	NP
Bench-Scale Vacuum-Assisted Dewatering Test	NP	(18-22) 37.1-42.5	NP
Pilot-Scale Vacuum-Assisted Sludge Dewatering Bed Testing	NP	(8-22) 22-38	NP
Pilot-Scale Plate and Frame Filter Press Test	NP	(8.2-22) 22.6-30.0	NP
Basket Centrifugation Test	NP	NP	(43.1) 46.7-50.4
Solid Bowl Centrifugation Test	NP	NP	(25.0-36.5) 40.0-47.8
Continuous Solid Bowl Centrifuge Test	NP	NP	(35.0) 25.2-51.2
Pressure Filtration	NP	NP	(36.5) 45-46
Trommel Screen Dewatering Simulation Test	NP	NP	(30.0) 32.6

Upper entry ( ) indicates the initial solids concentrations.
Lower entry indicates the final dewatered sludge solids concentrations.
All concentrations presented as percent total solids by weight.
NP = Test not performed.
*Test did not produce reportable results.

measurements. The EPA Environmental Response Team (EPA/ERT) took responsibility for constructing the vessels, which were designed by CH2M HILL. The flux chambers were basically sealed 55-gallon drums with agitation devices, headspace purging, and sampling apparatus. The flux chamber design is shown in Figure 4.

Two basic designs for the flux chambers were used; one that agitated dilute sludges, and one that raked thickened sludges. Freshly dredged bayou material at various dilutions was used in the testing. The intent was to simulate material handling operations that may be used during remedial activities. For example, a 20 percent solids mixture was tested in one of the agitated flux chambers to simulate a dilute sludge mixture that may be pumped into a dewatering feed tank. Flux measurements were recorded as agitation continued with these tests.

The raked tests used higher concentrations of sludge and an intermittent raking to simulate handling operations. For example, a 35 percent solids sample was tested to simulate a backhoe or clamshell bucket exposing a soil or sludge face during excavation. This test started with five quick revolutions of the internal rake mechanism. Following the initial raking, the test material was left undisturbed while flux measurements were recorded.

Sampling and analysis of gas emissions from the flux chambers used a variety of methods. An organic vapor analyzer (OVA) equipped with a flame ionization detector (FID) was used to indicate instantaneous nonspeciated organic flux magnitude. An OVA equipped with a photoionization detector (PID) with a 10.2-eV lamp was used as a second instantaneous measurement of nonspeciated organic flux magnitude. Samples were also collected in Tedlar bags, which were transported onsite to mobile support labs that used Ratfisch FID nonspeciated total hydrocarbon analysis, and GC--tandem mass spectrometry using the EPA's trace atmospheric gas analyzer (TAGA) mobile laboratory for speciated quantification of the emission stream. XAD-2 tubes were also employed as a sampling media and analyzed using GC methods in onsite labs.

The experimental plan was initially developed for 16 runs. Field modification of the plan resulted in the array of 23 runs shown in Table 4.

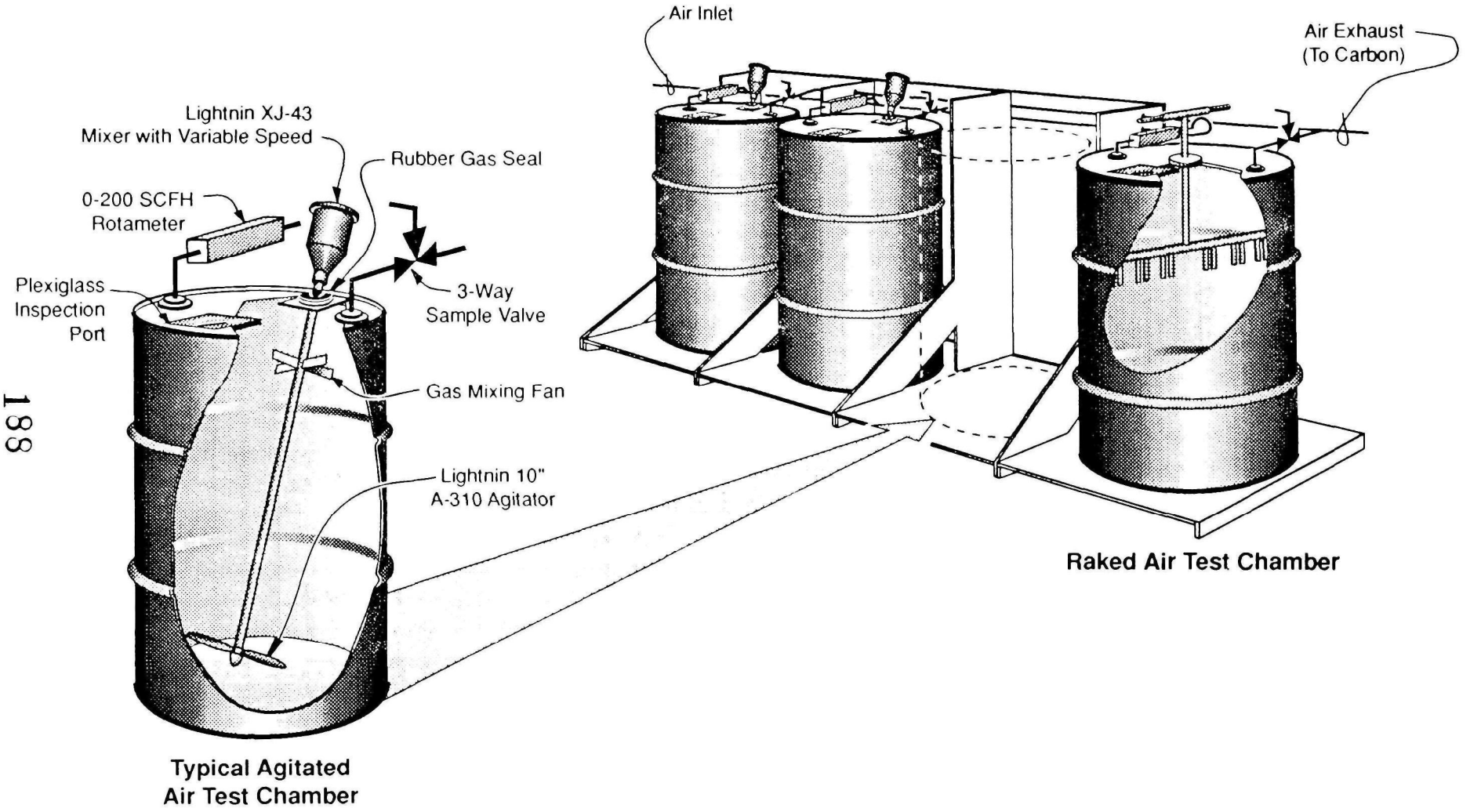


Figure 4
Air Test Chamber Design
Bayou Bonfouca
Slidell, Louisiana

Table 4
Experimental Plan for Air Emission Flux Testing

Sludge Composition	Type of Test	Comments
As dredged[a]	Stirred	4 runs
Diluted (high solids[b])	Agitated (low speed[c])	4 runs
Diluted (low solids[d])	Agitated (low speed)	4 runs
Diluted (high solids)	Agitated (high speed[e])	4 runs
Diluted (low solids)	Agitated (high speed)	4 runs
Diluted (low solids)	Agitated (high speed), heated	1 run
Diluted (low solids)	Agitated (low speed), oxidizer added @ 4:1 ratio[f]	1 run
Diluted (low solids)	Agitated (high speed), oxidizer added @ 4:1 ratio	1 run

[a]As dredged solids: 35 to 43 percent solids, 1.1 to 1.6 percent PNAs by weight.
[b]High solids: 14 to 37 percent solids and 0.68 to 1.01 percent PNAs by weight.
[c]Low speed: less than 185 rpm with 10-inch Lightnin A-310 impeller.
[d]Low solids: 8 to 19 percent solids and 0.43 to 0.66 percent PNAs by weight.
[e]High speed: greater than 185 rpm with 10-inch Lightnin A-310 impeller.
[f]Molar ratio of $KMnO_4$ to naphthalene in sludge samples.

The drums were all purged with filtered air at a rate of 100 scfh, which equates to approximately one headspace every 1.5 minutes. The purged air stream from each drum during a run was usually exhausted to a carbon canister. The purged stream was periodically diverted to sampling equipment through three-way valves. As shown in Figure 4, the headspace was thoroughly mixed during the agitated tests by means of a flat-blade fan mounted on the agitator shaft. Sampling intervals for the air tests were generally 15 minutes apart, while the duration of each test ranged from approximately 40 minutes to 2 hours.

Results

Pre-Pilot Study GC/MS characterizations performed with a bayou sediment sample indicated that there were around 100 hydrocarbon compounds in the headspace above the sediment sample. These results also indicated that there were approximately 10 ppm of nonmethane hydrocarbons in equilibrium with the sediment sample. The analysis was able to identify compounds that made up approximately 25 percent of the nonmethane hydrocarbon value. Based on this analysis and previous work, the following target compounds were identified:

- Naphthalene
- Benzene
- Toluene
- Xylenes
- n-Propylbenzene
- 1,2,4-Trimethylbenzene
- 1-Ethyl,2-methylbenzene
- 1-Propylbenzene

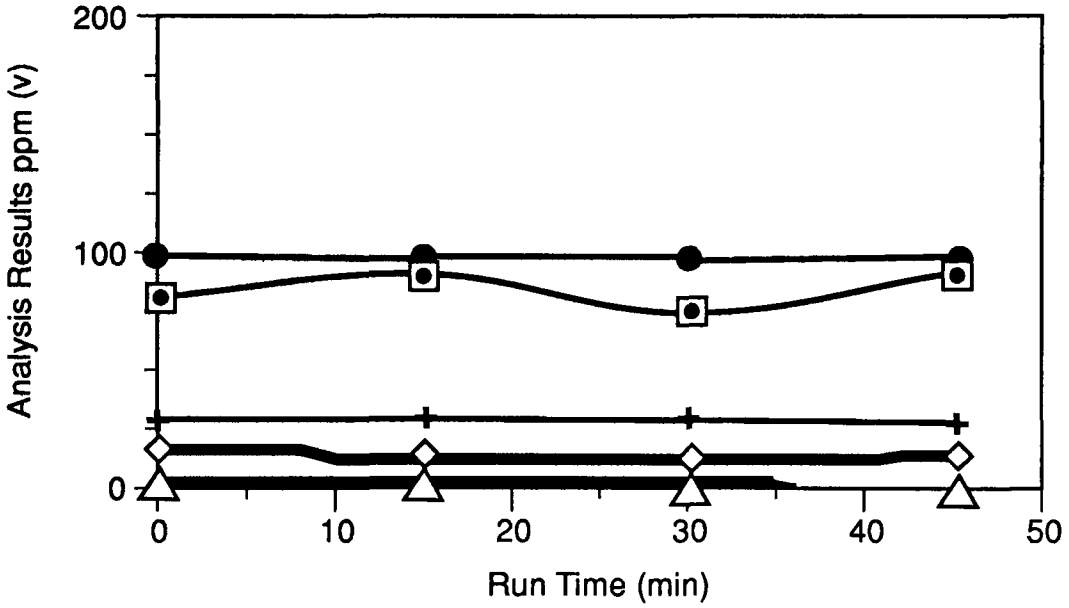
Trace atmospheric gas analyzer (TAGA) analysis by the EPA/ERT identified speciated compounds as either naphthalene, benzene, toluene, C2-benzenes, or C3-benzenes (C2 and C3 indicating the number of carbons attached to the benzene ring, in any configuration). The XAD-2 method was expected to speciate naphthalene and other PNAs. Ratfisch and OVA analyses with FID detectors measured total hydrocarbons (including methane), while the HNu PID detector gave results of total hydrocarbons without methane.

These five measurement techniques were used on each air test to analyze the exhaust purge air. Among four of the measurements (Ratfisch, TAGA, HNu, and OVA), some data spread is apparent for total hydrocarbon concentration. Data spread is attributed mainly to the following factors:

- Relative response was different with each instrument.
- The methane fraction was detectable only in the Ratfisch and OVA analyses. This resulted in higher total hydrocarbon concentration readings from these instruments, compared to the HNu or TAGA analyses.
- The TAGA data was target-specific to detect only naphthalene, benzene, substituted benzenes, and toluene. The TAGA results did not measure total hydrocarbons. TAGA data are therefore less inclusive than Ratfisch, OVA, and HNu measurements.
- Tedlar bags used to collect samples for Ratfisch and TAGA analyses were found to have lower naphthalene concentrations as time passed. This loss of naphthalene was assumed to be due to adsorption of naphthalene onto the inner wall of the Tedlar bag. Concentrations of benzene, toluene, and C2- and C3-benzenes were observed to remain constant over the same time periods. This loss of naphthalene was modeled as a first-order reaction and time corrected before reporting.
- Ratfisch analyses are known to have been performed on bags that had lost a fraction of the naphthalene sampled. Therefore, these samples were expected to exhibit results lower than real time OVA analyses on the same streams.

As an example, Figure 5 shows total hydrocarbon concentration data obtained from each of the emission measurement techniques during air test No. 5. Differences in instrument response may have contributed to differences in OVA versus Ratfisch and TAGA versus HNu results.

Comparison of XAD-2 results with those of other analytical techniques showed that XAD-2 results were inaccurate. Followup testing was initiated after completion of the pilot study in order to examine XAD-2 performance. This testing indicated that the



Legend:

- ✚ HNu
- ● OVA
- ⊡ Ratfisch
- ◇ TAGA
- △ XAD

Figure 5
Air Emissions Test
30% Solids, 270 rpm
Bayou Bonfouca
Slidell, Louisiana

particular XAD-2 tubes used for sample collection in the pilot study collected approximately one order of magnitude less of the compounds in question than another brand of XAD-2 tube. Further attempts were made to evaluate the performance of the pilot study tubes and apply correction factors to existing data. The results of this testing indicated that the performance of the pilot study XAD-2 tubes was not consistent or reproducible and the data could not be corrected.

Flux calculations were performed using the HNu and TAGA concentration results. The HNu total nonmethane hydrocarbon measurement was broken into fractions based on TAGA speciated results. Since the HNu data did not speciate organic compounds, these concentration readings included minor compounds that the TAGA did not include. The sum of TAGA speciated organics generally comprised 50 to 65 percent of the HNu readings. It was necessary to assign a composition to the HNu results to allow conversion from volumetric concentration data to mass flux data. It was assumed that the TAGA characterization was the best available, and that it provided an adequate distribution of molecular weights to characterize the HNu data. Table 5 shows the range of TAGA characterization data that was applied to HNu magnitude data.

Table 5
Concentration Ranges From Air Emission Testing

Compound(s)	Relative Percent Concentration Range[a]
Naphthalene	5.3 - 95
Benzene	0.3 - 24
Toluene	1.2 - 26
C2-Benzenes	1.7 - 32
C3-Benzenes	1.2 - 31

[a]These percentages are reported as relative, based on TAGA analytical results for the above target list of compounds/compound groups. The TAGA analyses do not account for numerous other minor air emission compounds that may be present.

The agitated and raked air tests resulted in total hydrocarbon concentrations generally around 80 to 100 ppm(v) by OVA, from 30 to 40 ppm(v) by HNu, and from 15 to 25 ppm(v) by TAGA analysis. The resulting flux values, calculated as explained in the previous paragraph, are presented in Table 6.

Table 6 Agitated Test Air Contaminant Flux	
Sediment Test	**Flux Rate ($\mu g/m^2$-s)**
Dilute Sediment-High Agitation	330 to 490
Dilute Sediment-Low Agitation	270 to 450
Nondilute Sediment-Raked	110 to 200
Dilute Sediment-High Agitation-Heated	730 to 1,100 (60 to 100°F, respectively)

The raked tests showed slightly lower fluxes than the agitated tests. The addition of $KMnO_4$ to test chambers had no observable correlation with reducing emissions. The heated test indicated that emissions did increase with temperature. For the heated test, naphthalene was observed as the main contaminant by TAGA analysis, ranging from 75 to 90 mass percent of the total contaminant concentration.

AIR DISPERSION MODELING

During the 1988 design investigations, CH2M HILL modelled air emissions expected to result from site remedial activities at Bayou Bonfouca using the industrial source complex--short-term air dispersion model (ISCST). Theoretical equations from the listed TSDF and AP42 references were used to model both organic and particulate flux from specific anticipated site activities. For this early effort, organic emissions were assumed to be 100 percent naphthalene. During the pilot study of November/December 1989, data were gathered on speciated mass flux, dewatering unit performance, and material handling characteristics. During the ensuing predesign, the remediation scenario and equipment layouts were revised. This section outlines the subsequent air modelling effort based on newly acquired contaminant flux and likely equipment layouts, which were developed following the pilot study.

Dispersion Model

Communication was incorporated early in this effort to include the EPA, LDEQ, and USCOE in the choice of models used, input format to the model, and output formats. The ISCST model was chosen based on past performance and applicability to the situation at Bayou Bonfouca. Two types of ISCST runs were performed. Individual sources were modelled using EPA-approved default atmospheric data. The individual sources were then combined into source runs that used New Orleans, Louisiana, meteorological data over a 1-year period.

Dispersion Model Inputs

Conceptual designs for equipment layout were used to situate area and point sources at the site. Pilot study flux values were used for most dredged sludge and sludge processing operations. TSDF flux estimates were used for modelling the wastewater treatment system, landfill operations, canal, waste pile, and contaminated soil excavations, while the AP42 model was used for particulate generation estimates associated with incinerator ash handling and dry soil excavation. These sources were all modelled as area sources in TSDF. Point sources included internal combustion engines and the incinerator stack.

To provide input to TSDF, remedial operations were broken into simple operations occurring over 8-hour work days. For example:

- Emissions from the dredging source were modelled to fit typical clamshell operations.
- A 1-cubic-yard bucket, with an associated surface area of 24 square feet of sludge, was assumed to be present above the water surface continuously.
- It was assumed that approximately every 2 minutes during the 8-hour work day the bucket would drop its 1 cubic yard of material, modelled as 1-foot-diameter spheres (with an associated surface area of 163 square feet) into a nearby barge for 15 seconds.
- During the time the empty bucket rotated back to the dredge, it would be dirty with contaminated sludge. This period was already taken into account by the assumption that a full bucket would be present over the water continuously.
- The storage barge was assumed to typically contain about 900 square feet of exposed sludge at any one time.
- Corresponding fluxes were assigned to the bucket, the drop, and the barge surfaces based on the pilot study fluxes for dilute sediment under low and high agitation, and nondilute sediment without agitation, respectively.

Other area sources were modelled similarly, with flux values from TSDF and AP42 being used where Pilot Study data were not available.

Pilot study flux values were compared to TSDF estimates for flux from the characterized sediment. TSDF estimates were based on a contaminant mixture of 50 percent naphthalene, 50 percent ethylbenzene, and various other variables including windspeed (10 mph), solids content, temperature, and specific total contamination concentration. For operations with dredged sediments, TSDF generally predicted flux in the range of 240 $\mu g/m^2$-s, while pilot study data

indicated fluxes for various operations ranging from 200 to 485 $\mu g/m^2$-s. This favorable comparison led to incorporating pilot study flux estimates for all dredged sediment operations, while TSDF was used to model flux from other remedial activities such as the wastewater treatment plant, excavations, and landfill operations. TSDF lent flexibility in incorporating changing process conditions such as contaminant concentration, moisture content, and material density from operation to operation. Many operations dealt with relatively dry materials or water streams to which pilot study data were not applicable.

There were two types of ISCST dispersion runs performed; individual source, and combined sources. The individual source runs were based on a screening data set of meteorological conditions. These conditions included various combinations of windspeed and atmospheric stability to provide estimates of the highest modellable downwind concentrations caused by individual sources. These runs used receptors positioned in one direction emanating out from the source. The meteorological data were entered with constant wind direction in the direction of the receptor line and the ISCST was configured to provide the highest concentrations observed at each receptor.

Combined source runs were based on two different remedial equipment layouts. Phase 1 was modelled to reflect equipment in operation during the initial preparation of the site, including waste pile excavation, the Eastern Drainage Channel and Western Creek excavations, and site preparation. Phase 2 was modelled to reflect continuous dredging of the bayou, dredged material handling and dewatering, incineration, and landfill disposal of ash. For each phase, modelling runs were performed.

Five years of meteorological data were obtained from New Orleans, Louisiana, from 1982 through 1986. These data were used to plot year by year and 5-year-period wind rose diagrams. These wind rose diagrams were used to observe the distribution of windspeed and direction. Based on the wind rose plots, 1982 was identified as the year most representative of the overall 5-year distribution and was used as ISCST input for all combined source runs.

The combined source runs used a receptor grid, which was centered about a point on the bayou bulkhead, and ranged to 5,000 meters (3.1 miles) in the north, southeast, and west directions. ISCST was then configured to provide the highest concentrations at each receptor experienced during any a 1-hour and 8-hour period in 1982, and the annual average concentrations experienced at each receptor point.

Dispersion Model Outputs

Individual source modelling results indicated a concentration gradient emanating from each modelled source in the downwind direction under the atmospheric conditions that produce the highest receptor concentrations. These gradients were plotted as

circles surrounding each source. The sources were then positioned on a site map. Figure 6 shows the highest-modelled receptor concentrations surrounding each source during Phase 2 of the remediation.

For example purposes, the concentrations plotted were chosen based on fractions of threshold limit values; TLV/42 and TLV/100 values for a mixture of 50 percent naphthalene and 50 percent ethylbenzene. The inner ring around a source is TLV/42, while the outer ring is TLV/100. These concentration values were plotted to give a preliminary idea of the areas possibly affected. They are not the risk-based action limits that were eventually developed for site remediation. These individual sources do not take into account compounded concentrations from combined sources. The dredge and barge locations shown in the southern bayou were positioned to indicate receptor concentrations when downstream dredging was in progress. Similar plots were developed for particulates as total suspended particulate (TSP) and respirable particulate (PM-10) during both Phase 1 and Phase 2 of remediation. Performing the runs sequentially, with a screening set of meteorological data, indicated the order of magnitude of receptor concentrations that were anticipated.

Combined source modelling was performed next; these results were presented in isopleths positioned on a site map. Figure 7 shows the isopleths resulting from the highest 1-hour receptor concentrations. One should note that these isopleths show the lateral extent of the highest concentration during any 1-hour period based on 1982 meteorological data. During an actual 1-hour period, wind direction would direct individual plumes away from the sources, not in all directions as shown. The compounded effect of multiple sources is illustrated on these plots.

This plot shows the modelling results from the 1-hour maximum concentrations of nonmethane organics during Phase 2. Similar plots were constructed for 8-hour maximum organic concentrations and annual average concentrations. Total suspended particulate (TSP) isopleth plots were also developed for these three scenarios. All six scenarios were then repeated for Phase 1 remedial activities.

The models were all intentionally constructed without emission controls (covers, foams, water sprays, etc.) on any of the sources. The final results were felt to be representative estimates of worst-case emissions that could be encountered during remediation. Knowledge of the magnitude of these concentrations also enabled air monitoring equipment to be specified. In addition, using the 1982 meteorological data and the anticipated equipment layout for the remediation allowed site-specific conversions from 1 hour to 8 hours and allowed annual average concentrations to be calculated. These factors are presented below:

- To convert 1-hour (maximum) receptor concentrations to 8-hour (maximum) concentrations, multiply by 0.29

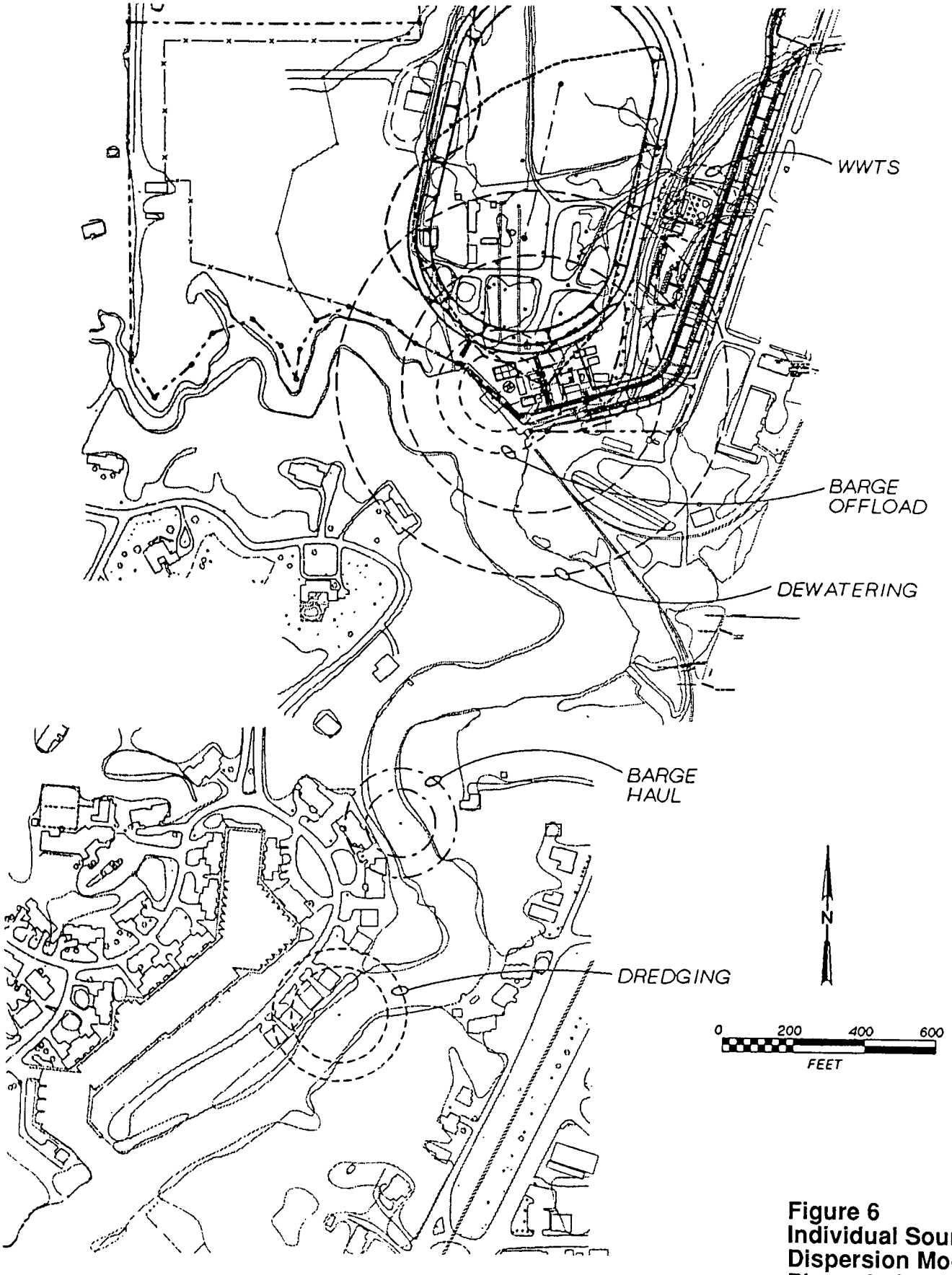


Figure 6
Individual Source Dispersion Modeling Phase 2, Organics
Bayou Bonfouca
Slidell, Louisiana

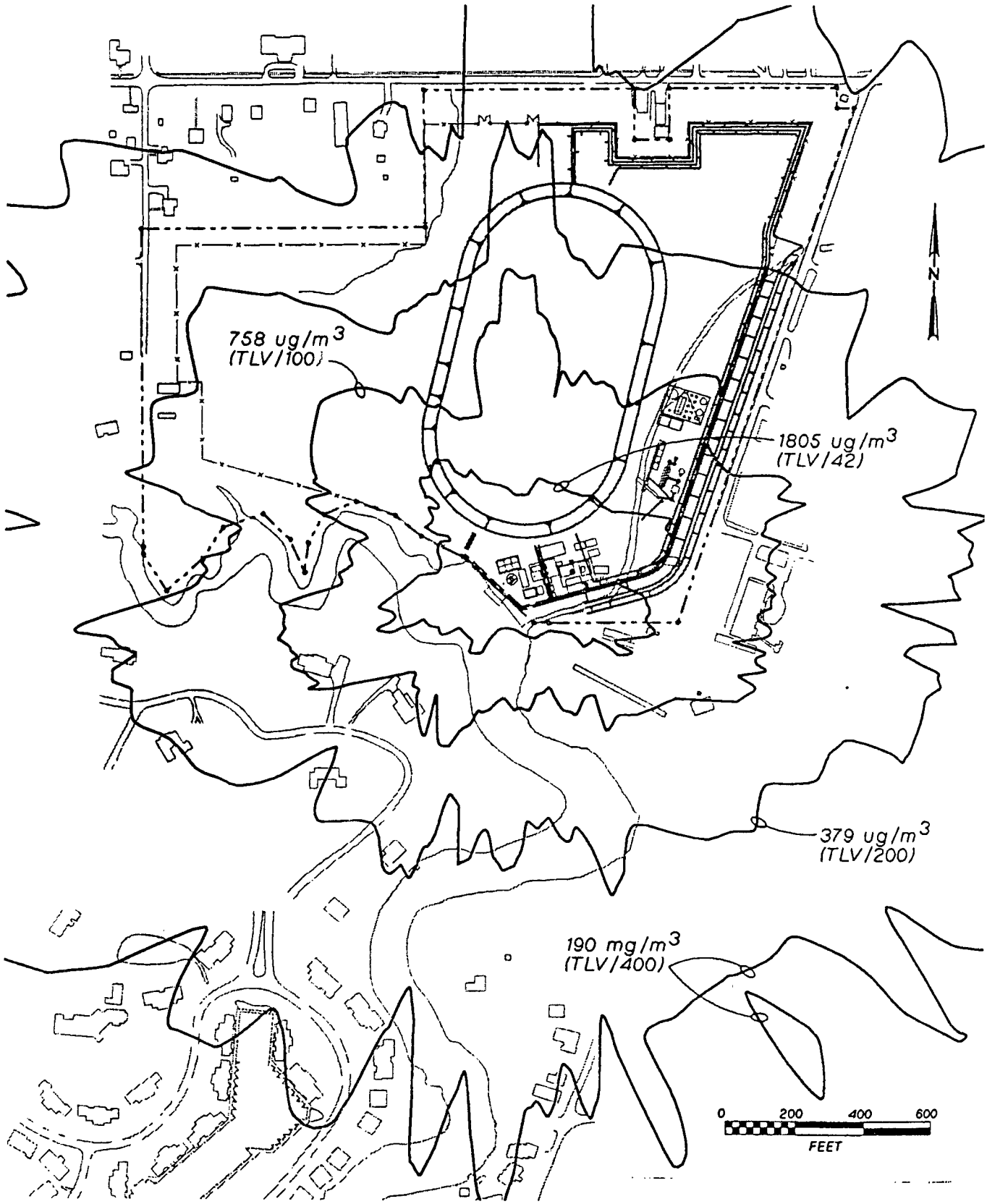


Figure 7
Combined Source Dispersion Modeling Phase 2, Organics
Bayou Bonfouca
Slidell, Louisiana

- To convert 1-hour (maximum) receptor concentrations to annual (average) concentrations, multiply by 0.012

This modelling effort also provided one workable method for estimating receptor concentrations, which could be used by remediation contractors to model actual remediation processes, and for optimizing necessary control measures based on EPA-developed risk-based action criteria.

CONCLUSIONS

The Bayou Bonfouca design investigations were planned as an integral part of the design and provided valuable input to help guide the development of design basis scenarios. The design basis scenarios were used for developing remedial action cost estimates and schedules, for structuring primarily performance-based design specifications, and for assessing probable remedial scope variance ranges. Supplemental design investigations were defined and performed, as directed by EPA, to address most areas of substantial scope uncertainty.

Other specific conclusions resulting from consideration of the Bayou Bonfouca Source Control OU design investigation results and completed remedial design include:

- The cost of the Bayou Bonfouca Source Control OU design investigations was approximately two percent of the current estimated cost for remediation. The refined scope definition and design benefits gained from the design investigation data provide strong support for this level of expenditure for this site.

- The field air contaminant flux testing functioned very well to define air emission flux ranges for various proposed remedial operations.

- The source-specific and combined source ISC computer dispersion modelling output was presented in the format of contaminant-specific concentration isopleths overlayed on a base site map with assumed locations for remedial operations. This format provided EPA with a powerful and convenient tool for assessing the impacts of proposed air contaminant action limits.

- The site remedial action will provide an excellent opportunity to collect air monitoring data to compare with the flux estimates and dispersion modelling results from the Bayou Bonfouca design investigation.

- The dewatering studies have identified possible process options for dredged sediment dewatering. Various dredging techniques may be used in the remediation and each

will produce sediment with a different range of solids concentrations. The costs associated with dredging, dewatering, and incinerator operation must all be weighed together in designing and implementing an optimum remedial process.

In summary, the design investigation efforts and subsequent air modelling efforts led to valuable design information for the remediation of Bayou Bonfouca. The data has been valuable to CH2M HILL, the EPA, USCOE, remediation contractors, and others in designing remedial activities, estimating air emissions, evaluating air contamination action limits, developing cost estimates, and developing bids that will eventually lead to the successful site remediation.

DISCLAIMER

This paper represents the opinions of the authors and is based on limited site investigation data. This paper does not represent a comprehensive summary or interpretation of existing site remediation data.

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Value Engineering Studies of the Helen Kramer Landfill Superfund Site

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INTRODUCTION

Construction of the selected remedial alternative at the Helen Kramer Landfill Superfund Site in Mantua, New Jersey is currently underway. URS Consultants, Inc., as prime contractor to the US Army Corps of Engineers, performed the detailed design of remedial alternatives at the site and is providing engineering services during construction. In response to several outstanding technical issues that arose during the detailed design, URS proposed and carried out a series of Value Engineering Studies. These studies identified a potential savings of $3 million by optimizing the design of remedial alternatives which had been proposed in previous designs. The proposed remedial plan, as stated in the USEPA Record of Decision (ROD) of 1985, consisted of a combination of slurry walls, subsurface drains, and a pretreatment facility. The reports which lead up to the design of the remedial action selected for use at the Helen Kramer Landfill site are as follows:

RI/FS	1985	R.E. Wright
ROD	September 1985	EPA
Design Analysis Report (DAR) 35%	January 1987	URS
Value Engineering Studies	December 1987	URS
DAR 65%	March 1988	URS
DAR 95%	June 1988	URS
DAR 100%	September 1988	URS
Final DAR & Final Specifications	May 1989	URS

The Value Engineering or VE studies performed by URS Consultants are the subject of this paper. The Helen Kramer site was the first Superfund remedial design to use this approach. Upon completion, the results indicated a substantial reduction in cost of the remedial action for the client, the Corps of Engineers.

BACKGROUND

The Helen Kramer Landfill site was ranked fourth on the USEPA's National Priorities List. It consists of a 66-acre refuse area and an 11-acre stressed vegetation area adjacent to the perennial stream Edwards Run, which is a tributary to the Delaware River. The site was initially a sand and gravel quarry before becoming a landfill in 1963. Between 1963 and 1981 the landfill received municipal, chemical, and hospital wastes. The wastes were dumped indiscriminately and resulted in contamination of surface water and shallow groundwater. The site layout is shown on Figure 1.

The remedial design outlined by the USEPA in their Record of Decision called for:

- Groundwater/Leachate collection and treatment,
- Clay cap,

- Upgradient slurry wall,
- Active gas collection and treatment,
- Dewater, excavate, and fill lagoons,
- Security fence, and
- Monitoring.

Upon reviewing the remedial design, URS identified a number of features which offered the potential for value engineering. The features selected were high-cost items whose implementation could, from a cost-effective standpoint, justify refinement and/or conceptual modification from the remedial measures suggested in the RI/FS. These modifications would still be in adhering to the ROD. The features which most availed themselves to value engineering were those pertaining to groundwater withdrawal and treatment. The VE studies agreed upon were as follows:

TASK 1VE - Develop Site Hydrogeologic Model

TASK 2VE - Establish Current Groundwater Regime

TASK 3VE - Water Balance Analysis

TASK 4VE - Assess Groundwater Table Rise

TASK 5VE - Cost-Benefit Analysis of Upgradient Subsurface Drain

TASK 6VE - Study of Slurry Wall Along Edwards Run

TASK 7VE - Assess Impact of the Higher Permeability of the Marshalltown

TASK 8VE - Downsizing of Treatment Facility

TASK 9VE - Develop Final Recommendations

DISCUSSION

The discussion of results is provided on a task-by-task basis.

TASK 1VE — Develop Site Hydrogeologic Model

The first task was dedicated to the development of a complete and computer useable geologic/hydrogeologic model of the area. This model utilized data gathered during the RI/FS and design investigations, published information for the area, and a current aerial photo of the site and vicinity. The model depicted the relationship between the three hydrogeologic units of interest at the site which are the shallow Mt. Laurel/Wenonah aquifer, the Marshalltown formation, and the Englishtown aquifer. In cross-section, these units appear as shown on Figure 2. Wastes were primarily deposited in the Mt. Laurel to the west of Edwards Run. Initial hydrologic properties of each of the units were determined by geometric averages of reported values (e.g. hydraulic conductivity). Initial piezometric heads were set to those felt to be representative of each of the three units as based on the USGS topographic maps for areas beyond the landfill site, and the aerial photo. Of particular note was the constant observance in piezometers and monitoring wells of upward flow from the Englishtown through the Marshalltown in the vicinity of Edwards Run. For this reason, Edwards Run was considered to be the eastern extent of the study area. The areal extent of the regional model's shown on Figure 3. A discretization of the regional model is shown on Figure 4.

TASK 2VE — Establish Current Groundwater Regime

In establishing the current groundwater regime for the Helen Kramer Landfill site, a two-phased approach was taken. First, a regional groundwater flow model was developed and calibrated to existing conditions using two calibration parameters. The first calibration parameter consisted of water levels in the onsite monitoring wells and piezometers, and calculated water levels in the surface features identified on the aerial photo and USGS topo maps. The second calibration parameter was discharge into Edwards Run. The latter was calculated with the aid of nearby gauged streams in the Delaware River Basin and approximated drainage areas.

In developing the regional model, offsite withdrawal wells (i.e. residential wells) were included in addition to important hydrologic features such as streams and ponds whose extents were taken from the aerial photo. The areal extent of the model was chosen so that the effect of boundary conditions would be minimal on groundwater flow near the landfill. The dimensions of the model extended 8,000 feet from east to west and 6,000 feet from north the south. The western boundary of the regional model lies approximately 5,000 feet beyond the western landfill edge. The eastern boundary of the model was Edwards Run, which is considered to act as a hydraulic barrier and a discharge point for both the Mt. Laurel and Marshalltown units given the aertisian conditions encountered in this area. All units were modeled to be laterally continuous across the region. The orientation of the model was chosen to parallel the bedding planes of the units in order to coincide with their general flow patterns.

The computer model used was MODFLOW, a Modular Three-Dimensional Finite-Difference Groundwater Flow Model by Michael McDonald and Arlen Harbaugh of the USGS (McDonald and Harbaugh, 1984). Version 1.0 was used for the Helen Kramer site VE Studies. Version 2.0 is currently being distributed which includes an automatic calibrator and post-processing interfacing with Auto-CADD to plot hydraulic heads and drawdowns. Version 2.0 of MODFLOW can handle 60,000 finite-difference cells, a substantial improvement over version 1.0, which was limited to less than 2,000. With MODFLOW, groundwater flow within the aquifer is simulated using a block-centered finite-difference approach. Layers can be simulated as confined, unconfined, or a combination of both. Flow from external stresses such as withdrawal wells, recharge, subsurface drains, and streambeds can be simulated. The model may be used for either 2D or 3D applications, and is capable of both steady-state or transient flow conditions.

In order to calibrate the regional groundwater flow model, steady-state conditions were simulated. Recharge was calculated within VE Study 3 (Task 3VE) and considered to be constant over the extent of the modeled area. Horizontal and vertical hydraulic conductivities were the parameters varied during the calibration process within the measured ranges as these values were the most variable. The hydraulic conductivity values which provided the "best fit" in getting the modeled water levels to match the observed water levels are shown in Table 1 along with other hydrogeologic parameters from the calibrated regional model.

Once the current groundwater regime was determined by the calibrated regional-scale model, the results were input into the local-scale groundwater flow model, discussed under Task 4VE, which was used to simulate site-specific perturbations of the groundwater flow regime in the immediate vicinity of the landfill (i.e., implementation of slurry walls, groundwater withdrawal, etc.). It was this local-scale model which provided the details necessary for the recommendations reached in these Value Engineering Studies.

TASK 3VE — Water Balance Analysis

Infiltration to the landfill is anticipated to contribute a significant amount of water to the groundwater regime. Using USGS topographic maps, historical meteorological data (from the National Oceanic and Atmospheric Administration for Philadelphia, PA, 1985), and runoff coefficients calculated using a weighted average for the watershed, infiltration rates were determined for the landfill and vicinity. Based on a 30-year period of record, precipitation in the vicinity of the Helen Kramer Landfill site is 41.42 inches per year. The Water Balance Method (Thornthwaite and Mather, 1955 and Fenn et al., 1975) was employed to calculate what percentage of that precipitation percolates through the ground surface to the water table. Results showed that approximately 25% of the precipitation percolated, 57% evapotranspired, and 18% became surface runoff. Twenty-five percent of 41.42 inches, or 10.5 inches/year was used as the steady-state infiltration rate under natural conditions at the site.

Once the landfill surface is capped, infiltration will be significantly reduced. In order to quantify this reduction, the Hydrologic Evaluation of Landfill Performance (HELP) computer model was used (Schroeder, et al., 1983). The proposed cap design consisted of a gas venting layer, two feet of low permeability material, drainage layer, frost protection, and topsoil. Results of the HELP model showed that infiltration through the clay cap would be reduced to approximately 1.6 inches/year, or 4 percent of average annual precipitation. This was the rate used over the extent of the landfill for capped conditions in the local-scale simulations.

TASKS 4VE and 6VE — Assess Groundwater Table Rise
— Study of Slurry Wall Along Edwards Run

Hydrogeologic parameters determined in the regional-scale model were used as input to the local-scale model. In particular, the regional-scale model provided steady-state water levels for all three layers where no monitoring wells had been located.

Three-Dimensional Local-Scale Model

The three-dimensional local-scale groundwater model was situated within the confines of the regional model as shown on Figure 5. The areal extent of the model was chosen such that one could examine the maximum potential groundwater table rise outside the northern, western, and southern slurry walls, and still provide the discretization necessary within the landfill. The eastern boundary was chosen to coincide with an idealized Edwards Run located 50 feet east of the planned leachate collection drain. For the purposes of comparative studies, this assumption was considered reasonable and was useful in keeping the model size and simulation time of the program within reasonable limits. This assumption was refined once the conceptualization of the remedial design was selected. At that point two-dimensional simulations were performed which more accurately represented actual conditions along the eastern edge of the landfill and vicinity. Two-dimensional simulations are discussed more fully at the end of this task.

The same three hydrogeologic units were considered in the local-scale model as in the regional model. However, the Marshalltown, which is considered to be a confining unit, was divided into two layers in order to simulate a variable depth of slurry wall key. That is, the Marshalltown which generally varies in thickness between 25 and 50 feet, was divided into a 5-foot layer and a 20 to 45-foot layer when simulating a 5-foot key; and into a 10-foot layer and a 15 to 40-foot layer when simulating a 10-foot key; etc.

Finite-difference cell widths varied from 3 feet, to represent the actual thickness of slurry wall and subsurface drains, to 900 feet in the central area of the landfill where a fine discretization was not

considered to be critical. The grid was developed to incorporate possible features such as slurry walls on all four sides and both upgradient and downgradient drains (collection or diversion).
The sixteen, three-dimensional transient cases shown in Table 2 were modeled with the calibrated regional-scale model conditions being equivalent to time zero. Each model was simulated for a period of 30 years. Variations among the first eight cases amounted to changing the depth of slurry wall key into the Marshalltown, and the elevation from which groundwater would be withdrawn from the downgradient drain. Accordingly, raising the downgradient drain height constituted adding a downgradient slurry wall which was not included in the ROD remedial design. The elevation of the drain was selected to be at elevation 20 feet which minimized the leachate withdrawal rate, but still maintained a positive inflow of groundwater from the Marshalltown (bottom) into the landfill. This ensured that no groundwater from the landfill would leak into the Marshalltown, bypass the collection drain and flow to Edwards Run. Results of the sixteen simulations are presented in Table 3.

It was shown that by raising the collection drain elevation from the proposed 6-inches below Edwards Run to an elevation of 20 feet, substantially less leachate would be withdrawn (28 vs 44 gpm). This would reduce both the size of the onsite treatment facility, and thus the capital costs as well as the annual operation and maintenance costs. The change in drain elevation, however, necessitates the addition of a downgradient slurry wall. The cost-benefit analysis of this addition was the subject of Task 8VE presented later.

It was further shown that the depth of the slurry wall key into the Marshalltown had a negligible effect on reducing the leachate withdrawal rate. This conclusion was of great significance in reducing the cost of the slurry wall design and construction.

Additional simulations were also performed under this task varying the hydraulic conductivity values of the units, and simulating 100-yr flood events for Edwards Run as detailed in Table 2. Simulation 6VE11 is dubbed the "bathtub". A "bathtub" was simulated by fully enclosing the site with a slurry wall, adding the selected cap, but not allowing for withdrawal of leachate from the landfill. This would be the case if for example, construction of these features was complete, but the treatment facility was not online. Results shown on Table 4 show that by two months, water within the landfill will rise to the top of the slurry wall along the eastern edge and exert pressure on the cap, possibly seeping through. This is a significant factor in establishing the construction schedule. It shows that there was little delay time between completion of slurry wall construction and the need for leachate withdrawal.

Simulations 4VE12 and 4VE13 simulated 100-year flood events in Edwards Run for cases of the downgradient slurry wall present, and downgradient slurry wall absent, respectively. While the duration of the flood event simulated was unrealistic, results showed that as expected, flows in the leachate collection drain would be significantly increased without the presence of the downgradient slurry wall. Where no slurry wall was present, flows increased from 45 gpm to 104 gpm over an 11 day period (the minimum time step printed); whereas when a slurry wall was in place, flows only increased from 28 gpm to 45 gpm.

Two-Dimensional Local-Scale Models

In order to more accurately define the irregular shape of the landfill near Edwards Run, a series of two-dimensional models was developed. The depth of slurry wall key was assumed to be 5 feet for all 2D simulations; all hydraulic conductivity values were the same as in the 3D local-scale model. The parameters varied were the distances and water levels between Edwards Run and the downgradient slurry wall and leachate collection drain. Figure 6 shows the location of the 2D sections with respect to the 3D grid. Figure 7 presents a discretization across a typical 2D section which shows

the finer grid along the eastern edge of the landfill to Edwards Run. Each of the 2D sections was analyzed separately and the results combined to determine total anticipated withdrawal rates.

The width of each of the 2D sections was kept equal to the width of the corresponding rows in the 3D model. Initial heads were derived from actual conditions, however, potentiometric levels within the Mt. Laurel were not permitted to rise above the ground surface during non-flood conditions. And finally, the Marshalltown was divided into 4 and 8 layers, (instead of just 2) for Sections C and D, respectively, for the purposes of developing a flow net.

Each cross-section was analyzed for two conditions, resulting in a total of twelve cases identified in Table 5. Cases 1 through 6 represent the lack of slurry wall on the downgradient side of the landfill, while Cases 7 through 12 represent its presence and the accompanying increase in collection drain elevation. The transient flow analyses were performed for a period of 30 years. Results are presented in Table 6.

Table 6 shows that steady-state flows to the leachate collection drain are 58.7 gpm (60 gpm) for the current design under normal Edwards Run flow conditions. These flows are reduced to 35.7 gpm (40 gpm) when a slurry wall in introduced between the drain and Edwards Run. Over a period of 30 years and using 60 gpm and 40 gpm rates in the analysis, this results in a total reduction of 315 million gallons of collected leachate.

TASK 5VE — Cost-Benefit Analysis of Upgradient Subsurface Drain

The previous analysis established that, due to the construction of slurry walls, the groundwater level to the north, west, and south of the landfill could rise by 2 to 3 feet over a period of 30 years. This increase in groundwater levels would cause an increase in the hydraulic gradient across the slurry wall and flow into the landfill either through the slurry wall, or the Marshalltown beneath it. It was therefore surmised that a subsurface drain constructed at the current groundwater level outside of the upgradient slurry wall could prevent such a condition. The cost-effectiveness of the upgradient drain was reviewed under Task 5VE by estimating the potential costs associated with the construction of the drain, and the potential savings in treatment plant capital and O&M costs resulting from reduced leachate flows attributable to this drain.

A three-foot wide French drain approximately 5,500 feet in length was assumed at a distance of 20 feet from the upgradient slurry wall. This placed the drain very close to the point where groundwater levels from the computer model were at a maximum. Three different depths were considered to achieve the following:

(1) maintenance of the existing water level (elev. 63 ft.);
(2) significant reduction in the water level (elev. 43 ft.); and
(3) moderate reduction in water level (elev. 53 ft.).

Case 4VE6 was used as the base case for comparison purposes which consisted of a cap, a fully-enclosing slurry wall with a key depth of 5 feet, and leachate collection drain at elevation 20 feet. The resulting flow rates are shown in Table 7. The costs estimated for construction of the upgradient drains, and the savings associated with leachate treatment are shown in Table 8. These estimates show that upgradient drain construction costs far outweigh any potential savings in reducing the cost of leachate treatment. This drain was therefore not recommended as part of the remediation.

TASK 7VE — Assess Impact of Higher Permeability of the Marshalltown

The Marshalltown, into which the slurry wall will be keyed, has been considered to be an aquitard. Large variations in permea- bility were measured in the laboratory varying from $3E^{-7}$ cm/sec to $2E^{-4}$ cm/sec. While still less pervious than the overlying Mt. Laurel and the underlying Englishtown formations, the Marshalltown's effectiveness in reducing flow into the landfill is expected to be less than what it would have ordinarily been if it were a true aquitard. The objective of this task was to make an assessment of the variations in leachate quantities that would be withdrawn given different permeabilities of the Marshalltown.

Again, Case 4VE6 was used as the base case. In this simulation, the horizontal conductivity value assigned to the Marshalltown was 0.254 ft/day ($9E^{-5}$ cm/sec), the vertical conductivity assigned was 0.0254 ft/day ($9E^{-6}$ cm/sec). Both of these values were the result of the calibrated regional-scale groundwater flow model. Variations of hydraulic conductivities were simulated as shown below:

7VE1 - Base case; slurry wall key at 5 feet
Marshalltown
Kh = 0.254 ft/day
Kv = 0.0254 ft/day

7VE2 - Increase values
Kh = 2.54 ft/day
Kv = 0.254 ft/day

7VE3 - Decrease values
Kh = 0.0254 ft/day
Kv = 0.00254 ft/day

7VE4 - Base case; slurry wall key at 20 feet

7VE5 - Use 7VE2; slurry wall key at 20 feet

7VE6 - Use 7VE3; slurry wall key at 20 feet.

Results are presented in Table 9. By increasing the hydraulic conductivity values by an order of magnitude, withdrawal rates almost doubled. That is, flow increased from 28 gpm to approximately 51 gpm for a 5-foot key depth; and from 29 gpm to 54 gpm for a 20-foot key depth. By decreasing the hydraulic conductivity of the Marshalltown, withdrawal rates decreased from 28 gpm to approximately 15 gpm for both depths of slurry walls. Both the increase and decrease in rates was attributable to upward flow to the Mt. Laurel through the Marshalltown on the eastern edge of the landfill. While these results indicate that withdrawal rates are sensitive to the hydraulic conductivity of the Marshalltown, a tenfold increase over the entire extent of the unit was felt to be unrealistic. Therefore, the pretreatment plant design capacity was not modified. If necessary, additional daily shifts could be added to reliably handle the flows that might arise if actual permeabilities were much greater than those previously measured.

TASK 8VE — Downsizing of Treatment Facility

During the preliminary design phase, groundwater collection rates were developed and a 300 gpm pretreatment facility was specified. The size of this pretreatment facility was dictated by the generally larger leachate volumes collected during the first two years of its operation. As the flow rates decrease with time, the required plant capacity also decreases. It was therefore prudent to study

ways to develop a more balanced design concept, and realize a cost savings resulting from such a design. The objectives of this task were: to develop cost estimates for various size (capacity) pretreatment facilities; to make an assessment of the technical viability of reducing the pretreatment plant size; to assess the placement of a slurry wall along Edwards Run; and to carry out a cost-benefit analysis for the slurry wall and the downsized facility that results.

In addition to the pretreatment facility, two additional designs were evaluated based on the withdrawal rates developed using results from the two-dimensional groundwater flow simulations in Task 4VE. The first design included a cap, upgradient, north and south slurry walls, and a leachate collection drain located on the downgradient edge of the landfill. The collection drain was located at a depth approximately 6 inches below the elevation of Edwards Run in order to maintain flow into the drain. The withdrawal rate associated with this first design was 58.7 gpm (approx. 60 gpm). The second design consisted of a fully-enclosing slurry wall (addition of a slurry wall along the downgradient side of the landfill) which allowed the collection drain to be located at an elevation of 20 feet. The withdrawal rate associated with this second design was 35.7 gpm (approx. 40 gpm).

Table 10 presents the flow rates for the three designs over a period of 30 years and the anticipated number of shifts per week required for operation of each facility. The original flow rates of 60 gpm and 40 gpm have been increased to process plant design flow rates as detailed in the table. The capital costs associated with the pretreatment plant construction were developed under this task. Preliminary design calculations had previously not included O&M costs for the pretreatment facility, therefore these were developed as well to allow comparison of the life-cycle cost of the alternatives. The leachate stream composition was assumed to be the same for all leachate flow rates and the same as determined in the Treatability Study performed for this site. An onstream factor was included to account for process down-time attributable to scheduled maintenance, process upsets, and potential equipment failure. Major components of the pretreatment process train are shown on Figure 8. All equipment was included with each of the three designs - that is, no equipment was left out of the reduced flow rate designs. Equipment sizes were reduced in proportion to the flow rates.

Estimation of the capital costs of each system was based on an in-depth assessment of the system components required. For each design, the system components were identified and sized on the basis of the character and volume of leachate to be treated. Table 11 presents the cost-benefit analysis of reducing the size of the pretreatment facility. Capital costs associated with the 180 and 120 gpm facilities, while similar, are substantially less than those for the 300 gpm facility. The 120 gpm facility has a slightly higher capital cost than the 180 gpm facility due to the construction of the downgradient slurry wall. In comparing O&M costs, the 120 gpm facility is substantially less costly. Overall then, the 120 gpm facility is anticipated to realize a $2.5 to $3 million savings in project cost (in 1988 dollars) over the 300 gpm design.

TASK 9VE — Develop Final Recommendations

The recommendations detailed in the Conclusions section of this paper were presented to the client based on the results of the Value Engineering studies. These recommendations provided for a savings in total project cost estimated to be over $3 million in 1988 dollars.

CONCLUSIONS

Upgradient Subsurface Drain

Analysis of results from Task 5VE established that remedial action implementation would cause only a small rise in the current groundwater level to the west, north, and south of the site. Costs analyses showed that the construction cost of a subsurface drain upgradient of the slurry wall would be greater

in comparison to the potential savings in reduced leachate flows to the downgradient drain. On the basis of these findings, it was therefore recommended that no upgradient drain be constructed.

Depth of Slurry Wall Key into the Marshalltown

Analyses performed in Tasks 4VE and 7VE showed that an increase in the depth of slurry wall key from 5 feet to greater depths has an insignificant impact upon flow patterns and withdrawal rates from the leachate collection drain. A 5-foot key, is sufficient to create a flow pattern which causes upward flow from the underlying Englishtown aquifer through the Marshalltown into the Mt. Laurel thus preventing downward migration of leachate from the landfill into the underlying units. This reduced the cost of the slurry wall in both the detailed design and during construction.

Slurry Wall Along Edwards Run and Downsizing of the Pretreatment Facility

Results of Task 4VE showed a significant reduction in withdrawal rates from the leachate collection drain with the addition of a downgradient slurry wall along Edwards Run, and raising the elevation in the drain to 20 feet. Based on results of the two-dimensional simulations, the flow rates to the drain were reduced from approximately 60 gpm to 40 gpm. The offsetting cost for constructing the downgradient slurry wall was estimated at close to over $1 million. The reduction in flow rates corresponds to a potential for downsizing the pretreatment facility for a total overall savings of $2.5 - $3 million (in 1988 dollars) in both capital and O&M costs. In addition, enclosing the landfill with a slurry wall provides for full containment and offers greater overall reliability in leachate collection, as well as provides a mitigative effect on the site from flooding of Edwards Run.

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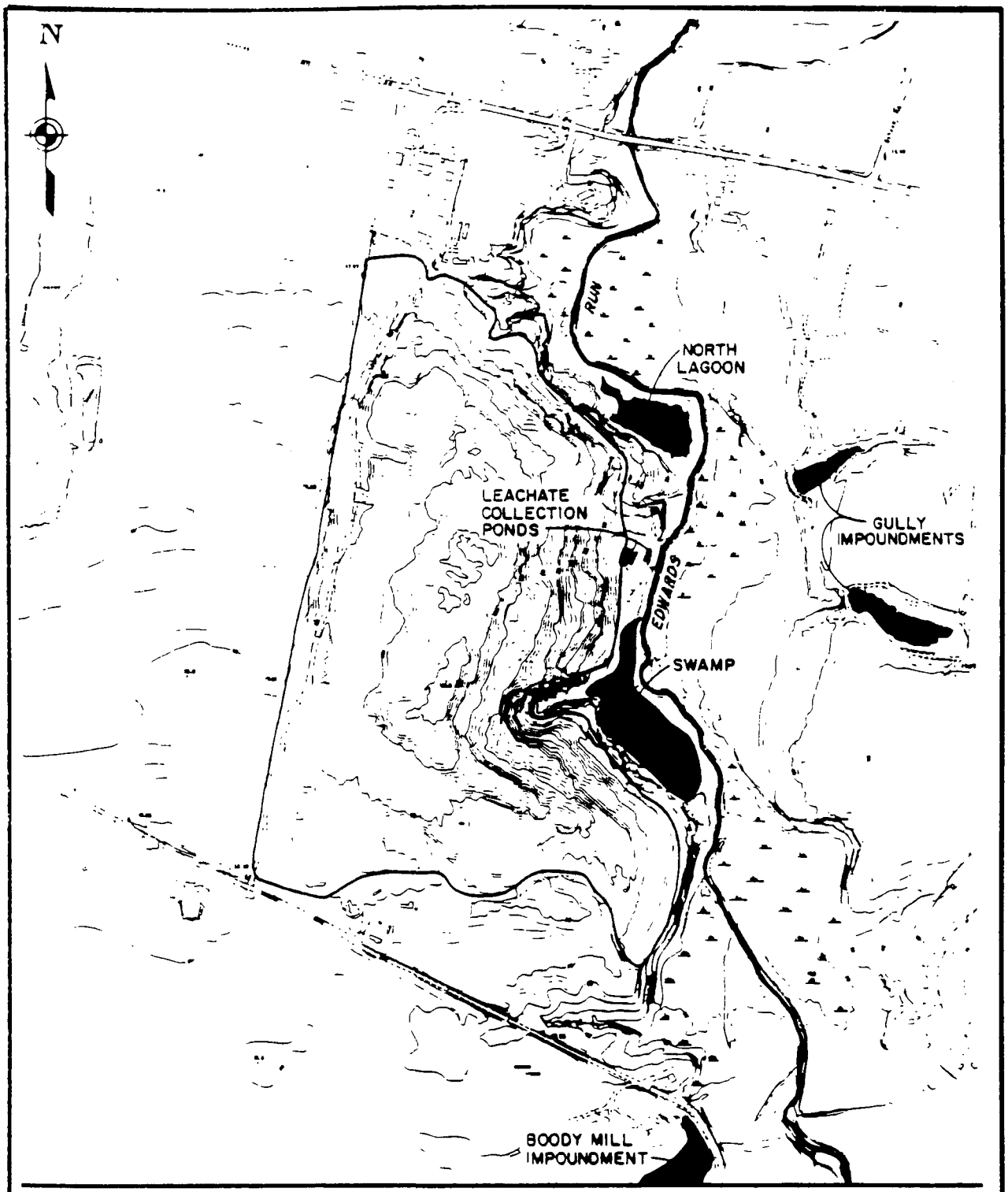


LEGEND

SURFACE WATER BODIES

SWAMPY AREAS

400' 0 400

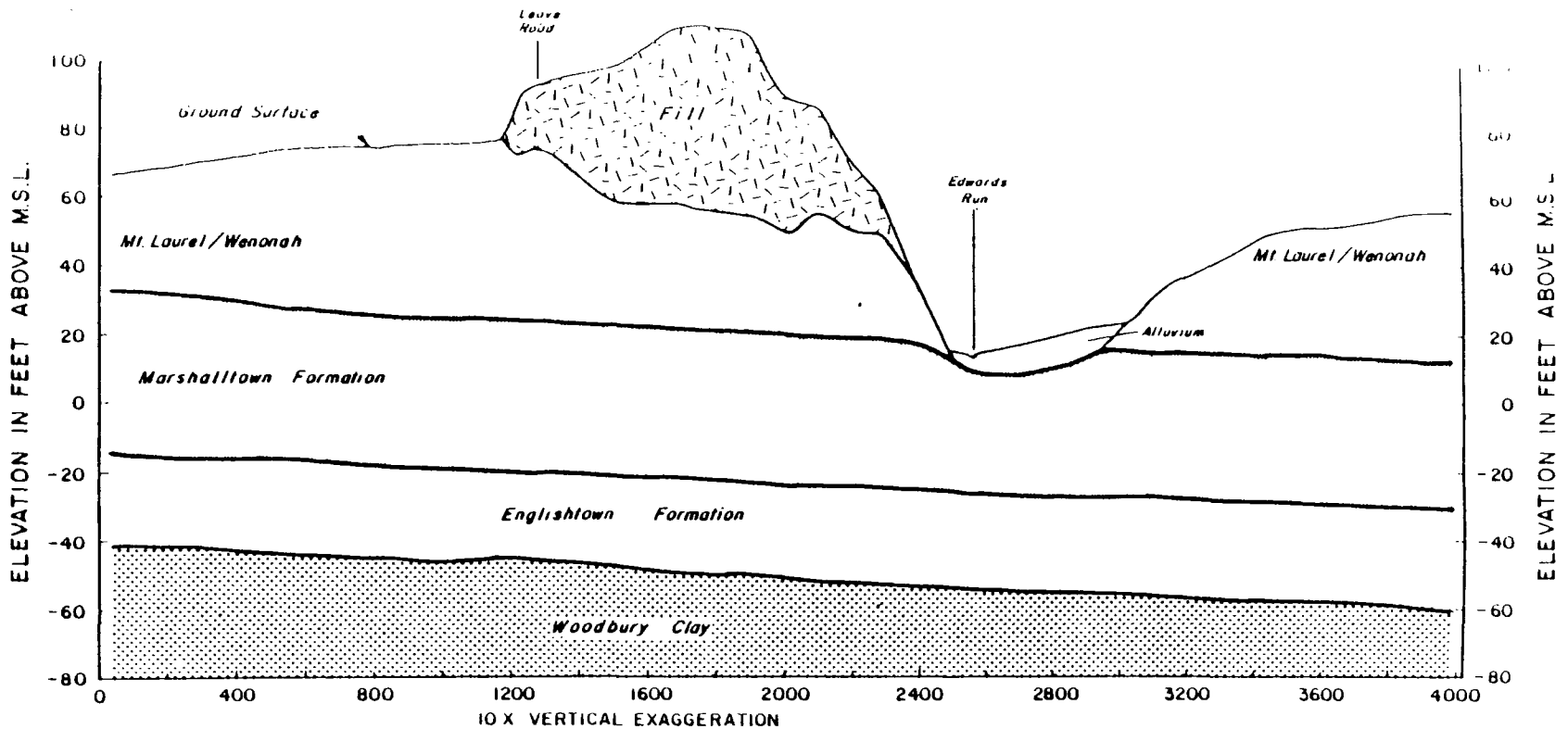
SCALE IN FEET

REFERENCE: RI/FS FIGURE 5-2 (R.E. WRIGHT, 1986)

URS CONSULTANTS, INC.	SITE LAYOUT	FIGURE 1

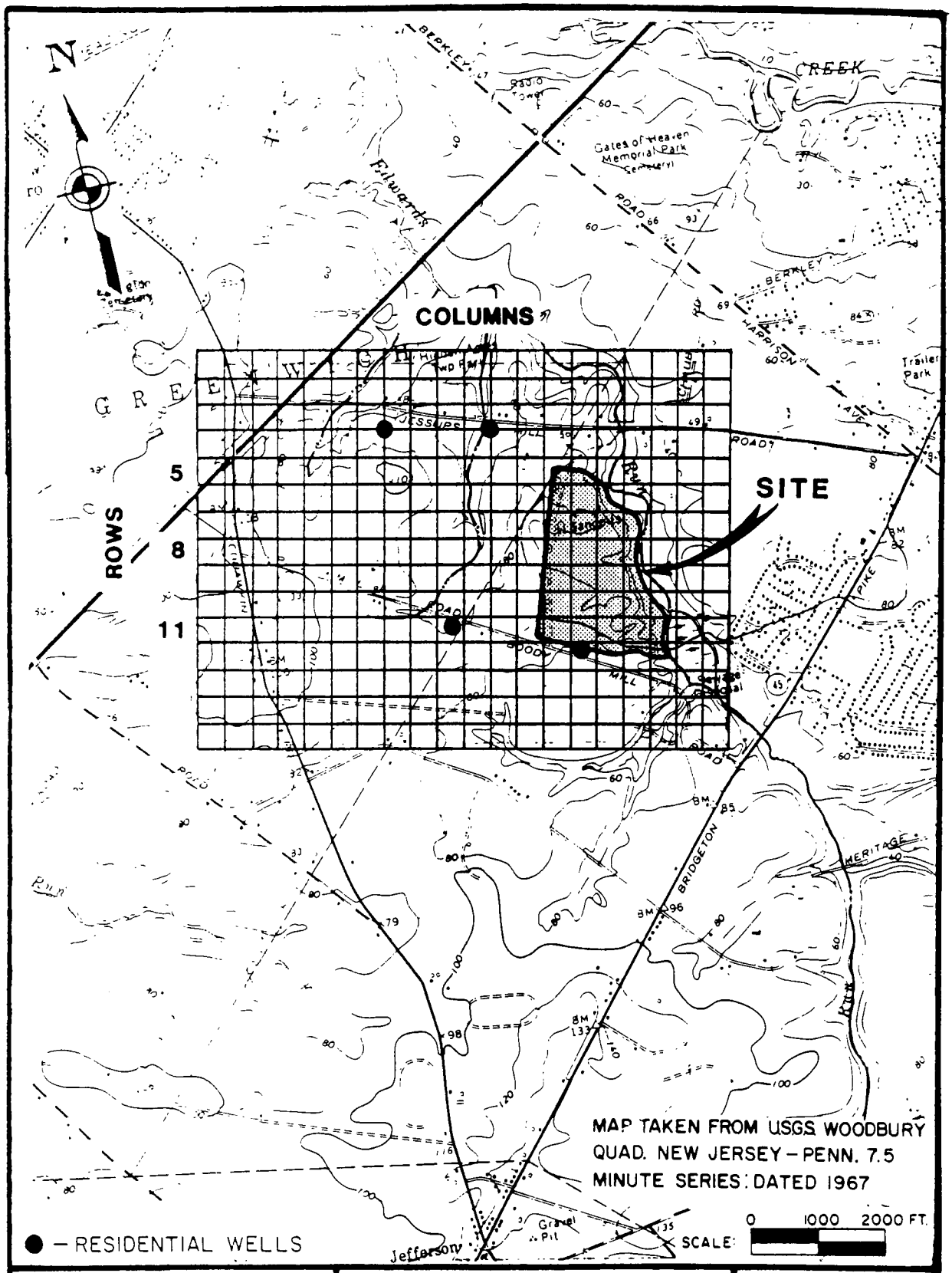
A-3693

A-3694



REFERENCE: RI/FS FIGURE 4-3 (R.E. WRIGHT, 1986)

URS CONSULTANTS, INC.	CROSS-SECTION OF HYDROGEOLOGIC UNITS	FIGURE 2



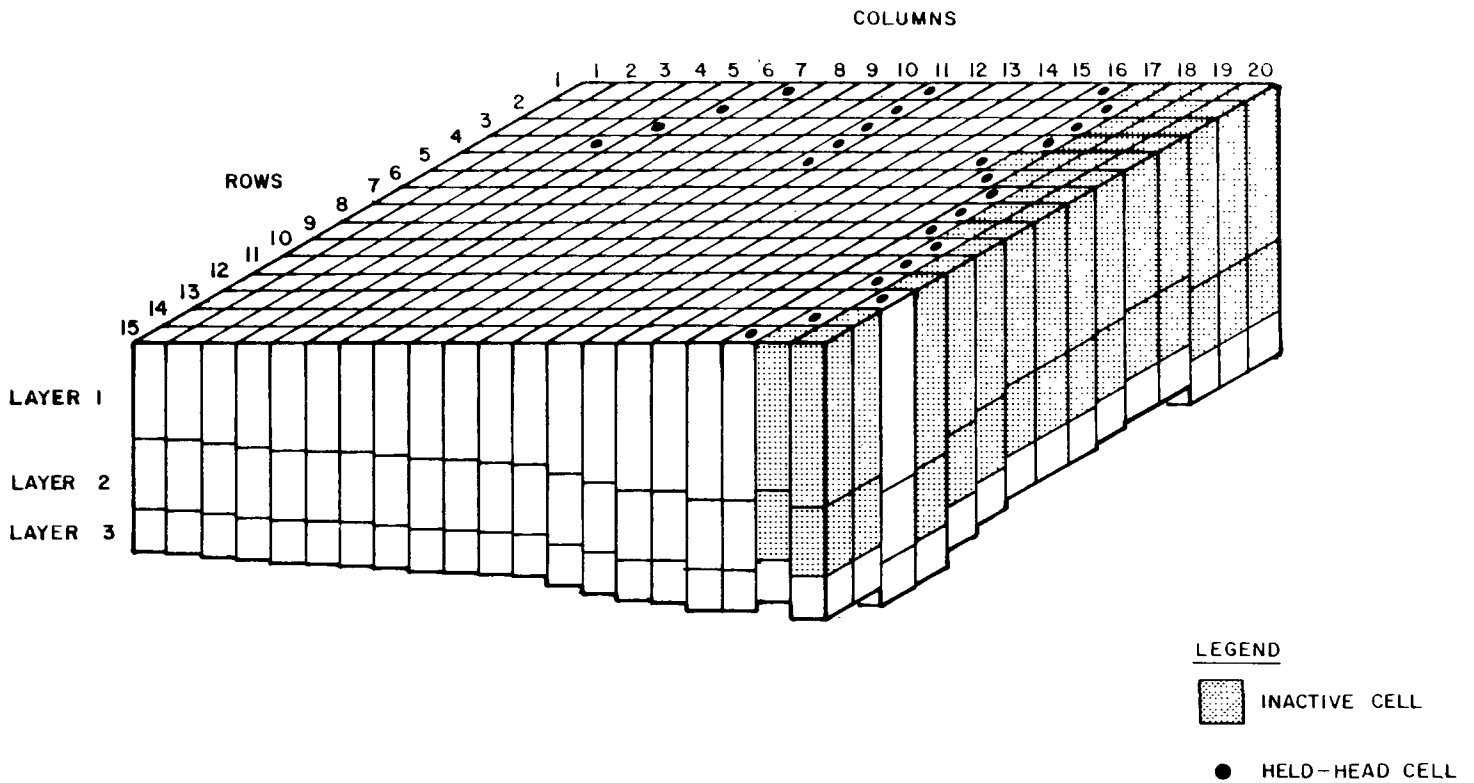
URS CONSULTANTS, INC.

AREAL EXTENT OF REGIONAL GROUNDWATER MODEL

FIGURE 3

A-3695

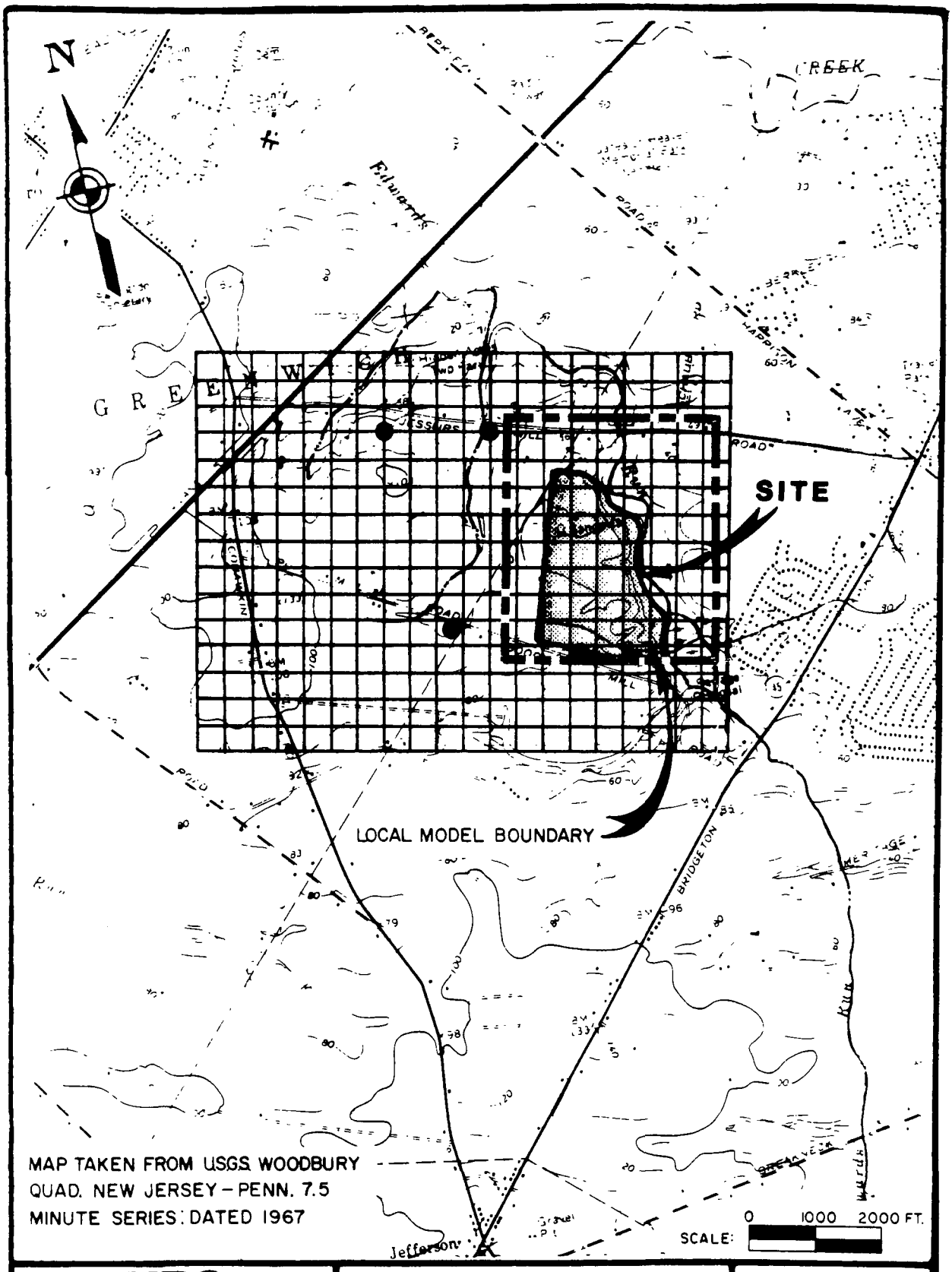
A-3696



URS CONSULTANTS, INC.

DISCRETIZATION OF REGIONAL GROUNDWATER SYSTEM

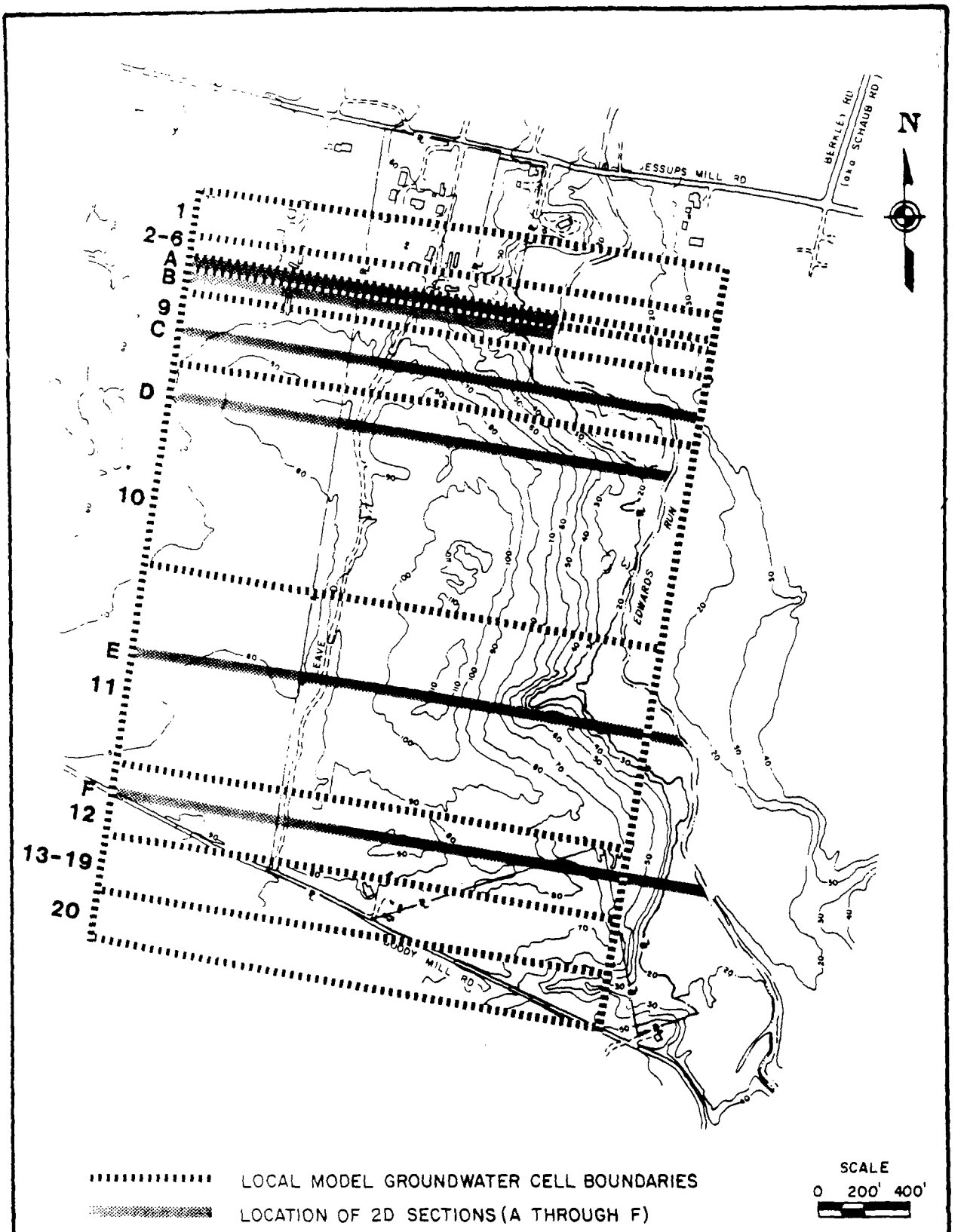
FIGURE 4



URS CONSULTANTS, INC.

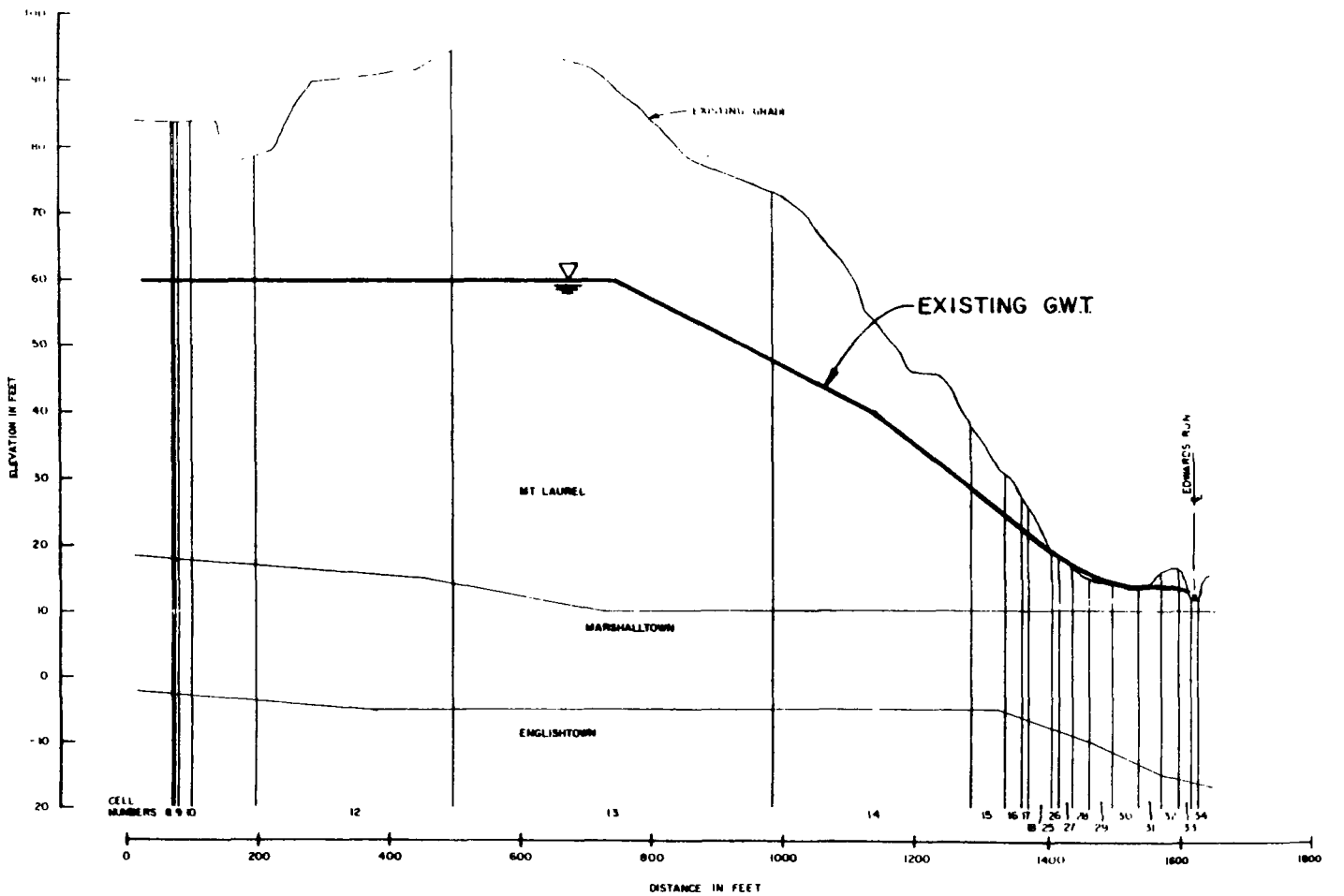
LOCATION OF LOCAL GROUNDWATER MODEL

FIGURE 5



URS CONSULTANTS, INC.	LOCATION OF 2D SECTIONS	FIGURE 6

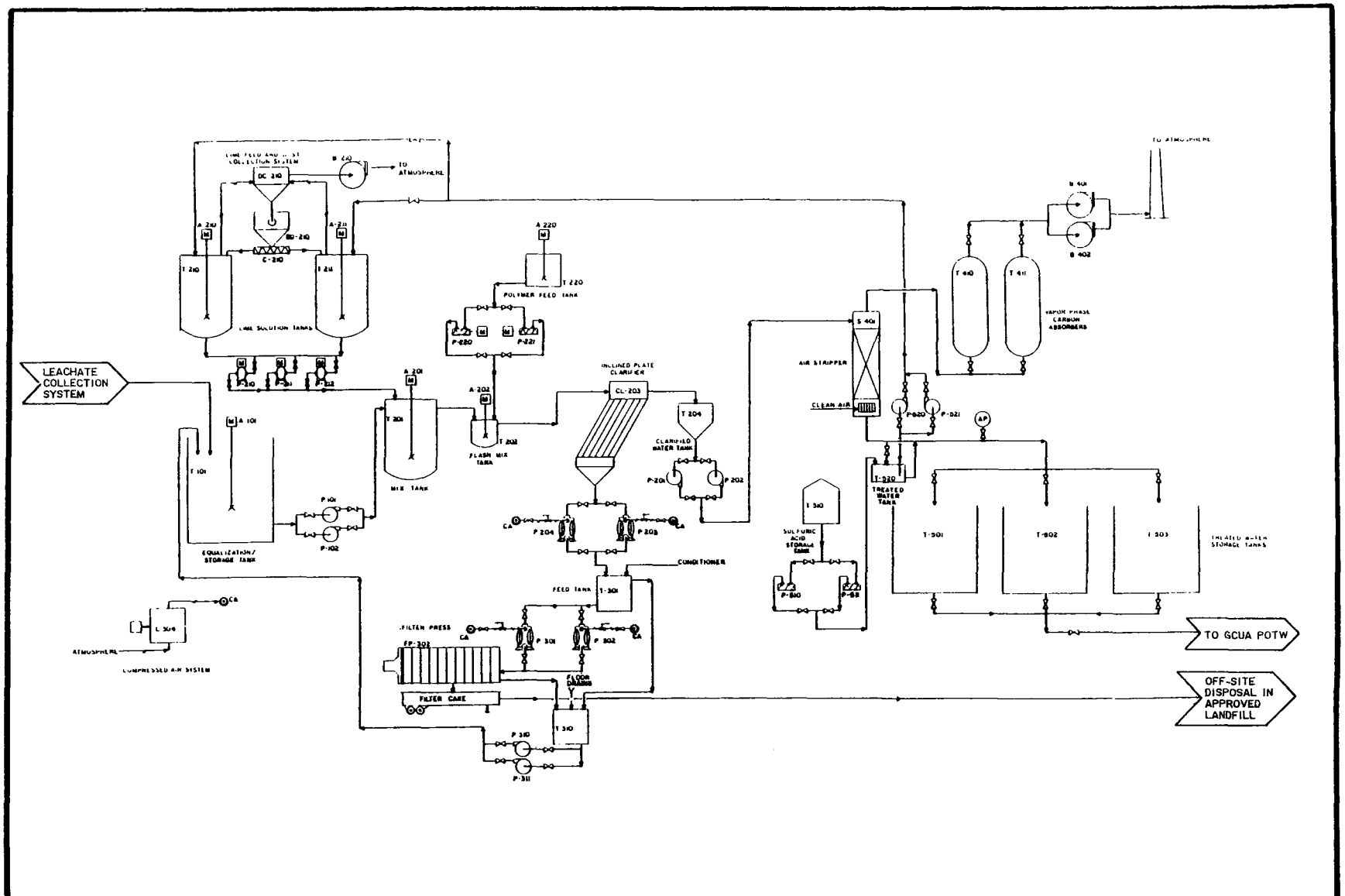
A-3699



URS CONSULTANTS, INC.

DISCRETIZATION OF TYPICAL 2D CROSS-SECTION

FIGURE 7



URS CONSULTANTS, INC.

PRETREATMENT FACILITY FLOW DIAGRAM

FIGURE 8

TABLE 1

DATA FOR LOCAL SCALE GROUNDWATER FLOW MODEL

Parameter	Mt. Laurel	Marshalltown	Englishtown
HYDROGEOLOGY			
Horizontal hydraulic conductivity (cm/sec)	$7E^{-4}$	$9E^{-5}$	10^{-2}
Vertical hydraulic conductivity (cm/sec)	$7E^{-5}$	$9E^{-6}$	10^{-2}
Porosity	0.35	0.40	0.25
Fluid density (kg/m^3)	1.000	1.000	1.000
Unit saturated thickness	variable	25-40 ft	25 ft
Edwards Run water levels adjacent to site	8.5 to 15.5 ft		
Infiltration	Natural - 10.5 in/yr Capped - 1.6 in/yr		
Length of simulations	30 years		

TABLE 2
DESCRIPTION OF CASES 1 - 16

RUN #	DIMENSION	UPGRADIENT DRAIN DEPTH FROM W.T. (ft.)	SLURRY WALL KEY INTO MARSHALLTOWN (ft.)	DOWNGRADIENT DRAIN WATER LEVEL ELEVATION (ft.)	DOWNGRADIENT SLURRY WALL	NOTES:
CASE 1 4 VE 1	3 D	NONE	NONE	6" BELOW E.R.	NONE	
CASE 2 4 VE 2	3 D	NONE	5	6" BELOW E.R.	NONE	
CASE 3 4 VE 3	3 D	NONE	10	6" BELOW E.R.	NONE	
CASE 4 4 VE 4	3 D	NONE	20	6" BELOW E.R.	NONE	
CASE 5 4 VE 5	3 D	NONE	NONE	20	NONE	
CASE 6 4 VE 6	3 D	NONE	5	20	YES	
CASE 7 4 VE 7	3 D	NONE	10	20	YES	
CASE 8 4 VE 8	3 D	NONE	20	20	YES	
CASE 9 4 VE 9	3 D	NONE	5	20	YES	INCREASED K IN MT. LAUREL
CASE 10 4 VE 10	3 D	NONE	5	NONE	YES	ENCLOSED SYSTEM
CASE 11 4 VE 11	3 D	NONE	5	NONE	YES	ELIMINATE DOWNGRADIENT DRAIN
CASE 12 4 VE 12	3 D	NONE	5	20	YES	SIMULATE 100 YR. FLOOD FOR 30 YRS.
CASE 13 4 VE 13	3 D	NONE	5	6" BELOW E.R.	NONE	SIMULATE 100 YR. FLOOD FOR 30 YRS.
CASE 14 4 VE 14	3 D	NONE	5	6" BELOW E.R.	NONE	INCREASED K IN MT. LAUREL
CASE 15 4 VE 15	3 D	NONE	5	20	YES	INCREASED K IN MT. LAUREL
CASE 16 4 VE 16	3 D	NONE	5	6" BELOW E.R.	YES	AND MARSHALLTOWN

TABLE 3
GROUNDWATER FLOW RATES FOR CASES 1-16

RUN #	TIME = 11 DAYS					TIME = 1 YEAR					TIME = 30 YEARS				
	L W	L E	U	N & S	TOT FLOW TO DRAIN (ft^3/d) (gpm)	L W	L E	U	N & S	TOT FLOW TO DRAIN (ft^3/d) (gpm)	L W	L E	U	N & S	TOT FLOW TO DRAIN (ft^3/d) (gpm)
CASE 1 4 VE 1	10,237	2,045	187	76	12,545 66	6,848	1,522	120	62	8,552 45	6,796	1,519	124	62	8,501 45
CASE 2 4 VE 2	10,481	2,169	273	78	13,001 68	6,619	1,505	165	64	8,353 44	6,556	1,503	170	64	8,293 44
CASE 3 4 VE 3	10,685	2,282	264	79	13,310 70	6,644	1,538	163	64	8,409 44	6,585	1,535	161	64	8,345 44
CASE 4 4 VE 4	10,675	2,290	233	80	13,278 69	6,602	1,550	142	64	8,358 44	6.543	1,547	140	64	8,294 44
CASE 5 4 VE 5	7,567	0	121	0	7,688 40	5,093	0	62	0	5,155 27	5,044	0	62	0	5,106 27
CASE 6 4 VE 6	7,751	330	156	0	8,237 43	4,848	351	78	0	5,277 28	4,805	349	78	0	5,232 28
CASE 7 4 VE 7	7,941	404	165	0	8,510 45	4,914	394	83	0	5,391 28	4,864	394	83	0	5,341 28
CASE 8 4 VE 8	7,979	404	160	0	8,543 45	4,957	418	84	0	5,459 29	4,906	417	84	0	5,407 29
CASE 9 4 VE 9	42,533	288	144	0	42,965 224	16,604	266	57	0	16,927 88	16,541	265	57	0	16,863 88
CASE 10 4 VE 10					N / A					N / A					N / A
CASE 11 4 VE 11					N / A					N / A					N / A
CASE 12 4 VE 12	7,794	657	161	0	8,612 45	4,964	410	87	0	5,461 29	4,922	408	87	0	5,417 29
CASE 13 4 VE 13	11,043	8,390	126	307	19,866 104	6,926	7,272	111	210	14,519 76	6,862	7,267	111	209	14,449 76
CASE 14 4 VE 14	50,106	8,308	79	280	58,773 306	20,387	7,091	62	170	27,710 144	20,300	7,089	62	170	27,621 144
CASE 15 4 VE 15	53,259	2,131	522	0	55,912 291	27,360	1,517	311	0	29,188 152	27,026	1,508	309	0	28,843 150
CASE 16 4 VE 16	62,919	4,243	915	0	68,077 354	33,648	3,144	673	0	37,465 195	33,311	3,133	671	0	37,115 193

LEGEND:

LW = LATERAL FLOW THROUGH THE MT. LAUREL FROM WEST
LE = LATERAL FLOW THROUGH THE MT. LAUREL FROM EAST
U = UPWARD FLOW FROM THE MARSHALLTOWN
N & S = INFLOW FROM NORTH AND SOUTH AT THE EASTERN END OF THE SLURRY WALL

TABLE 4

GROUNDWATER LEVELS FOR CASE 11

Row	Top of Slurry Wall (ft)	Time (months) 1	2	3	4	5
7	25	23.3	24.5	24.9	25.0	25.1
8	25	23.2	24.4	24.8	25.0	25.0
9	25	23.2	24.5	24.9	25.1	25.1
10	25	23.3	24.6	25.1	25.3	25.3
11	25	23.9	25.2	25.7	25.9	25.0
12	25	24.3	25.6	26.1	26.3	26.3
13	29	24.4	25.7	26.2	26.3	26.4
14	29	24.9	26.1	26.6	26.7	26.8

TABLE 5

SUMMARY OF 2-D MODEL ANALYSIS CASES

Case	Run	2-D Cross-Section	Upgradient Slurry Wall Key Depth (ft)	Downgradient[1] Drain Water Level Elevation (ft)	Downgradient Slurry Wall Key Depth (ft)
1	6VE1	A	5	10.1	NONE
2	6VE2	B	5	10.2	NONE
3	6VE3	C	5	10.5	NONE
4	6VE4	D	5	11.1	NONE
5	6VE5	E	5	13.1	NONE
6	6VE6	F	5	13.8	NONE
7	6VE7	A	5	20.0	5
8	6VE8	B	5	20.0	5
9	6VE9	C	5	20.0	5
10	6VE10	D	5	20.0	5
11	6VE11	E	5	20.0	5
12	6VE12	F	5	20.0	5

(1) These levels varied with the level of Edwards Run for cases 1 through 6.

TABLE 6
GROUNDWATER FLOW RATES TO LEACHATE COLLECTION DRAIN

RUN #	TIME = 11 DAYS				TIME = 1 YEAR				TIME = 30 YEARS			
	L W	L E	U	TOT FLOW TO DRAIN (ft^3/d) (gpm)	L W	L E	U	TOT FLOW TO DRAIN (ft^3/d) (gpm)	L W	L E	U	TOT FLOW TO DRAIN (ft^3/d) (gpm)
6 VE 1	510	145	13	668 3.5	223	113	10	346 1.8	222	113	10	345 1.8
6 VE 2	365	151	13	529 2.8	263	137	11	411 2.2	262	137	11	410 2.2
6 VE 3	1,525	666	45	2,236 11.7	917	597	38	1,552 8.1	916	597	38	1,551 8.1
6 VE 4	4,343	1,677	132	6,152 32.0	2,947	1,316	104	4,367 22.7	2,947	1,316	104	4,367 22.7
6 VE 5	4,604	2,072	100	6,776 35.2	2,244	1,124	54	3,422 17.8	2,235	1,121	54	3,410 17.8
6 VE 6	2,267	525	40	2,832 14.8	908	291	20	1,219 6.4	893	290	19	1,202 6.3
TOTAL	13,614	5,236	343	19,193 99.8	7,502	3,578	237	11,317 58.8	7,474	3,574	236	11,285 58.7
6 VE 7	436	12	6	454 2.4	180	20	4	204 1.1	179	20	4	203 1.1
6 VE 8	286	10	5	301 1.6	220	22	4	246 1.3	219	22	4	245 1.3
6 VE 9	1,277	55	21	1,353 7.1	760	79	16	855 4.5	762	79	16	857 4.5
6 VE 10	3,493	199	68	3,760 19.6	2,407	223	46	2,676 13.9	2,401	223	46	2,670 13.9
6 VE 11	3,974	188	60	4,222 22.0	1,936	122	25	2,083 10.9	1,917	122	25	2,064 10.8
6 VE 12	2,022	92	27	2,141 11.2	783	53	10	846 4.4	767	52	10	829 4.4
TOTAL	11,488	556	187	12,231 63.6	6,286	519	105	6,910 35.9	6,245	518	105	6,868 35.7

LEGEND:

LW = LATERAL FLOW THROUGH THE MT. LAUREL FROM WEST
LE = LATERAL FLOW THROUGH THE MT. LAUREL FROM EAST
U = UPWARD FLOW FROM THE MARSHALLTOWN

TABLE 7
FLOWS TO LEACHATE COLLECTION DRAIN

RUN #	TIME = 11 DAYS				TIME = 1 YEAR				TIME = 30 YEARS			
	L W	L E	U	TOT FLOW TO DRAIN (ft^3/d) (gpm)	L W	L E	U	TOT FLOW TO DRAIN (ft^3/d) (gpm)	L W	L E	U	TOT FLOW TO DRAIN (ft^3/d) (gpm)
CASE 6 CH 6 4 VE 6	7,751	330	156	8,237 43	4,848	351	78	5,277 28	4,805	349	78	5,232 28
CASE 1 5 VE 1	7,745	329	156	8,230 43	4,827	348	78	5,277 28	4,740	346	77	5,163 27
CASE 2 5 VE 2	7,741	329	156	8,226 43	4,691	343	77	5,277 27	4,642	341	76	5,059 27
CASE 3 5 VE 3	7,735	328	156	8,219 43	4,535	334	75	5,277 26	4,476	332	74	4,882 26

LEGEND:

LW = LATERAL FLOW THROUGH THE MT. LAUREL FROM WEST
LE = LATERAL FLOW THROUGH THE MT. LAUREL FROM EAST
U = UPWARD FLOW FROM THE MARSHALLTOWN

TABLE 8

COMPARISON OF UPGRADIENT DRAIN CONSTRUCTION COSTS AND LEACHATE TREATMENT COST SAVINGS

Elevation	Construction Costs	Cost Savings (1)	
		10% Discount	6% Discount
63 ft MSL	$6,025,310	$0	$0
53 ft MSL	$6,844,410	$63,000	$92,000
43 ft MSL	$8,482,610	$126,100	$184,200

(1) Cost savings based on a 120-gpm pretreatment plant.

TABLE 9

COLLECTION DRAIN FLOW RATES WITH CHANGING MARSHALLTOWN CONDUCTIVITY (in gpm)

Time	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
11 days	43	75	29	45	79	30
1 yr	28	51	17	29	54	17
30 yrs	28	51	15	29	54	15

TABLE 10

LEACHATE FLOW RATES TO COLLECTION DRAIN
(GPM)

Year	Phase II Design	Case I	Case II
1	216	58.8	35.9
2	165	58.7	35.8
3	95	58.7	35.7
4	70	58.7	35.7
5	50	58.7	35.7
6-30	19	58.7	35.7
Flow rates selected for design	216	60	40
Flow rate for process design	300(1)	180(2)	120(2)

(1) Phase II design assumed 21 shifts/week (continuous) operation in Year 1, 15 shifts/week operation in Year 2, 10 shifts/week in Years 3 and 4, and 5 shifts/week for Years 5-30.

(2) Case I and Case II designs assume 10 shifts/week operation throughout the 30-year estimated life cycle of the facility. The Case I flow rates are for estimated leachate flows collected without the installation of a downgradient slurry wall. Case II flow rates are the estimated leachate rates when a downgradient slurry wall is installed between the leachate collection drain and Edwards Run.

TABLE 11

TOTAL PRESENT WORTH COSTS
($1000)

	10% Discounting			6% Discounting		
	Phase II 300 GPM Facility	Case I 180 GPM Facility	Case II 120 GPM Facility	Phase II 300 GPM Facility	Case I 180 GPM Facility	Case II 120 GPM Facility
Capital Cost						
Treatment Facility	5,333	4,012	3,198	5,333	4,012	3,198
Downgrad. Slurry Wall	---	---	859	---	---	859
Subtotal	5,333	4,012	4,057	5,333	4,012	4,057
O&M Cost	5,093	5,034	3,783	7,436	7,351	5,524
TOTAL	10,426	9,046	7,840	12,769	11,363	9,581
Savings from Downsizing to 180 GPM		1,380			1,406	
Savings from Downsizing to 120 GPM			2,586			3,188

Remedial Action in and Around Light Industrial Activity at the Denver Radium Superfund Site

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ABSTRACT

The Denver Radium Superfund Site consists of 16 separate sites located along the South Platte River Valley in Denver. Contamination at the sites is the result of widespread radium processing which occurred between 1914 and 1927. Operable Unit I of the Denver Radium Site covers one city block and is the former location of a radium-processing facility. Currently, the site is zoned for light industry and is occupied by five small businesses: (1) a warehouse/wholesale operation; (2) a sheet-metal assembly business; (3) an appliance repair business; (4) a hardware fabrication business; and (5) a grave-marker manufacturer.

The primary challenge presented by the site is that of removing approximately 33,000 tons of radiologically contaminated soils and debris and, at the same time, allowing the businesses on site (none of which are responsible parties) to maintain a semblance of normal operations. This required multiple phasing of the decontamination and reconstruction work in order to maintain access to the site for routine business operations. Four of the structures on site were underlain by contamination which required relocating the businesses to allow for demolition of the floors and excavation of the subgrade. This was accomplished by bringing mobile office space onto the properties and by temporarily relocating business operations into previously vacant space.

In order to transport waste from the site in the most expeditious and cost-effective manner, EPA' contractor renovated a rail spur that had been abandoned for more than 50 years. This allowed bulk transportation of contaminated material in dedicated railroad gondola cars. To maximize the efficiency of the loadout operation, an in-rail scale was installed at the Operable Unit along with a gantry to facilitate the placing of hard lids on the railcars. Prior to and during the rail renovation work, loadout of contaminated material was performed using 20-ton, truck-mounted containers.

BACKGROUND

Operable Unit I (OU I) of the Denver Radium Site is a 7.33 acre site that lies within the South Platte River valley in an industrialized area of the Denver. Radium contamination at the site resulted from the processing of radium ores by the Pittsburgh Radium Company during 1925 and 1926. This company went bankrupt in 1926 as did most of the domestic radium industry when extremely rich radium deposits were discovered in the Belgian Congo. The radium-contaminated materials at OU I were subsequently forgotten until 1979 when an Environmental Protection Agency (EPA) employee looking through old Bureau of Mines publications saw reference to the radium industry in Denver.

The Record of Decision (ROD) for OU I, signed on September 27, 1987, called for capping the exterior contamination at the site and excavating all contamination beneath structures and storing it on site until a permanent deposal repository could be located. Plans for on-site storage were abandoned shortly after the signing of the ROD when a commercial disposal facility in Tooele County, Utah, was granted a license to accept radium wastes. Consequently, the remedial design focused on excavation and direct off-site disposal of the radiologic contamination.

Standards for cleanup at inactive uranium mill sites (40 CFR 192) were identified in the ROD as the relevant and appropriate cleanup levels. These standards state that the remedial action should be conducted to provide reasonable assurance that the concentration of radium-226 when averaged over an area of 100 square meters does not exceed background by more that 5 picocuries per gram (pCi/g) in the top 15 cm of soil or 15 pCi/g in soil deeper than 15 cm.

OVERVIEW OF THE DECONTAMINATION PROCESS

Radiologic contamination at the Denver Radium Sites is excavated in six-inch lifts in order to minimize the amount of "clean material" that is removed with the waste. After a lift has been removed, the excavation is surveyed to determine whether it is necessary to remove another lift. The practice of excavating six inches at time is based on average length of the travel path of gamma rays emitted by radium-226 and associated radionuclides (approximately 8 inches in soil).

The determination as to what material exceeds the cleanup criteria is made by field personnel measuring gamma-exposure rates using hand held scintillometers. Once the field instrumentation indicates that the cleanup standards have been met, a final verification survey is performed by collecting composite samples from the excavation and analyzing the samples in a van equipped with an Opposed Crystal System (OCS). The OCS is a gamma spectroscopy device which provides more accurate radium concentration data than the field instruments because it can distinguish the gamma radiation being emitted by radium-226 from that being emitted by other naturally occurring radionuclides (e.g. potassium-40 and thorium-232).

The cleanup work at the Denver Radium Site is being performed by two contractors: a design/construction contractor and a transportation and disposal contractor. The design/construction contractor is responsible for the following activities:

1. Gathering additional characterization data to supplement the data collected during the remedial investigation.

2. Developing design documents.

3. Procuring and directing an excavation subcontractor.

4. Maintaining site health and safety.

5. Performing any sampling necessary for characterizing the contents of transportation containers.

The transportation and disposal (T&D) contractor brings transportation containers to the site where they are loaded, decontaminated if necessary and released by the design/construction contractor. The transportation and disposal contractor then places hard covers on the containers and ships them to the disposal facility. Approximately 85 percent of the waste that has been shipped from the Denver Radium properties has gone via railroad gondola cars (100 ton capacity). The remainder has been

shipped via 20-ton, truck-mounted containers which are loaded at the site and driven to a Denver rail yard where they are placed on flatbed rail cars for shipment to the disposal facility.

HEALTH AND SAFETY

Remedial action workers at OU I performed the majority of the cleanup work in "Level D" protection. This level of personnel protection was possible due to the emphasis placed on dust suppression. The low technology approach of thoroughly wetting the excavation proved highly effective and generally kept the concentrations of hazardous substances in the air well below permissible exposure limits. Large fans were used during interior work to vent radon gas to the outside atmosphere. Air monitoring for respirable dust, airborne radionuclides and metals was conducted in the controlled areas using high volume samplers. In addition, portable, low-volume samplers were utilized to gather breathing zone data for workers in areas where the potential for exposure was high.

Personnel protection was upgraded to "Level C" during two periods of site activity: 1) when transformers were discovered in a septic tank; and 2) when workers complained of a pesticide odor when working in the vicinity of a leaky underground storage tank. "Modified Level D" equipment (tyvek coveralls, gloves and booties) was donned during bad weather periods when muddy conditions increased the likelihood of picking up radiologic contamination.

PHASING OF REMEDIAL CONSTRUCTION

EPA Region VIII made the determination that the current property owners at OU I could successfully assert innocent landowner defenses to CERCLA liability. For this reason, EPA attempted to conduct the remedial action in a manner that would minimize the disruption to the on-site businesses. To this end, the response action was conducted in three phases:

Phase A	Exterior areas west and south of the Warehouse/Wholesale Company building (west building) (Figure 1).
Phase B	Interior Contamination in the west building.
Phase C	Remaining exterior and interior areas.

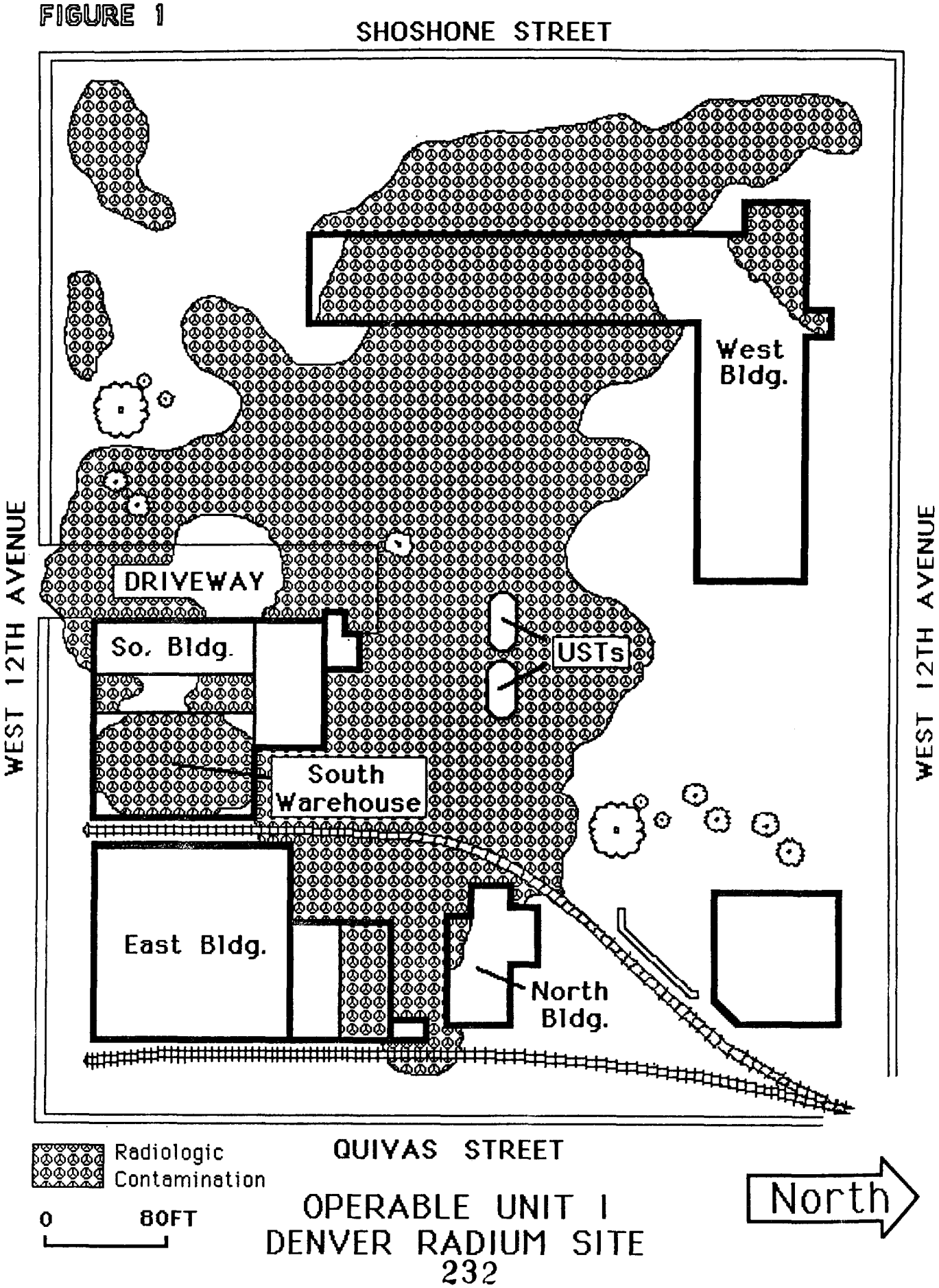
PHASE A

Data gathered during the remedial investigation and remedial design indicated that contamination in the west building was located beneath the southern wing of the structure (a 16,000 square foot warehouse) and in an office area on the northern end of the building (Figure 1). EPA originally intended to rent off-site warehouse and office space to temporarily dislocate the operations in the contaminated portions of the building so that excavation of the radium-tainted soils could occur. However, at the owner's request EPA was able to implement the following plan that eliminated the need to rent off-site warehouse and office space:

1. EPA's contractor excavated 1950 tons of radium contamination from the exterior area west of the west building.

2. The property owner entered a separate contract with the excavation contractor to decontaminate the area south of the west building (565 tons removed). EPA provided technical oversight.

FIGURE 1



OPERABLE UNIT I
DENVER RADIUM SITE

3. Radiologic contamination was loaded into 20-ton, truck-mounted containers.

4. EPA's contractor then performed a final verification survey to assure that the cleanup standards had been met.

5. Upon completion of the verification survey, the owner contracted for the construction of a new warehouse in the area south of the existing building with the intention of vacating the existing warehouse upon completion of the new one (Figure 2).

During the course of the Phase A work, the transportation and disposal contractor proposed the renovation of an abandoned rail spur located immediately west of the grave marker manufacturer's building (North Building, Figure 2) so that the remaining material on site could be loaded into 100 ton gondola cars. Recognizing the logistical advantages of using gondolas instead of truck-mounted containers, EPA agreed to allow loadout by rail provided that it resulted in no additional cost to the government. The main problem presented by the rail loadout, was that in order to place material into gondolas located on the spur, the contaminated material would need to be hauled up a very steep grade that separated the warehouse/wholesale property from the grave-marker manufacturer and hardware fabrication properties (Figure 3). The T&D contractor intended to surmount this obstacle by installing a conveyor to take material from the lower level of the site to the track level (an elevation difference of approximately 27 feet).

The renovation of the rail spur took eight weeks and involved lifting the buried rails, adding ballast material, replacing 75 percent of the railroad ties, and the installation of a railroad crossing on a very busy thoroughfare. During the renovation work, the T&D contractor installed an in-rail scale that was accurate to within plus or minus 50 pounds. The scale enabled rail cars to be loaded to near capacity and eliminated the problem of overloading (which at other Denver Radium OUs had resulted in having to bring approximately 18% of the gondolas back to the site for partial off loading). The configuration of the spur and the location of the scale limited the number of gondolas that could be on site at any time to three. The T&D contractor erected a gantry immediately outside of the controlled area which enabled two workers to secure the 10 by 52 foot, 1,200 pound hardcovers on the loaded gondolas in less than 10 minutes per container.

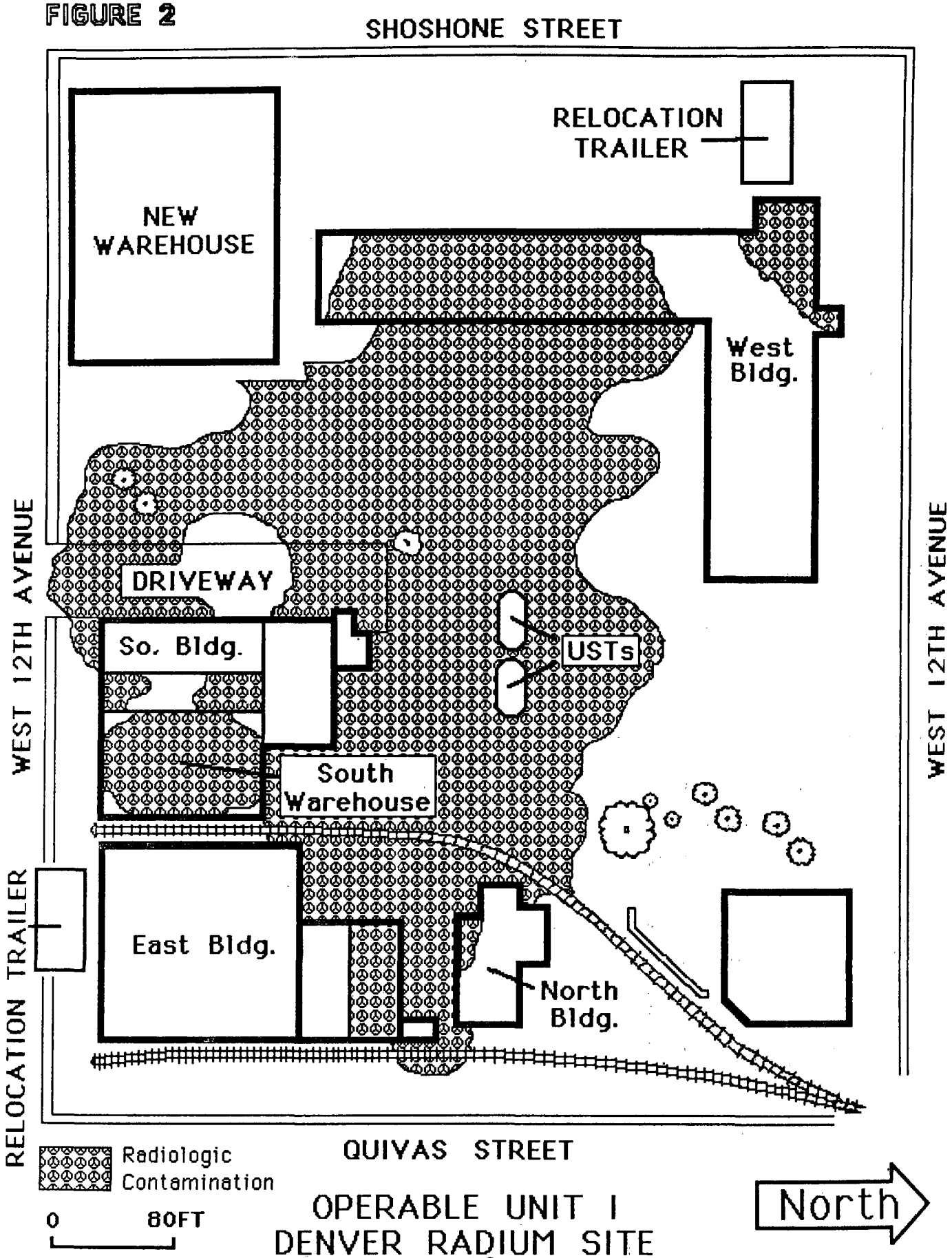
PHASE B

During the construction of the new warehouse, remedial action began in the office and showroom portion of the west building. Thirteen office workers were relocated to trailers in the parking lot west of the building (Figure 2). EPA's contractor then erected airtight barriers to isolate the controlled area from the rest of the building, removed the office partitions, removed the floor covering, and jackhammered the floor to expose the contaminated subgrade. Radium contaminated soils (564 tons) were removed via small conveyors and skip loaders and put into dump trucks that were driven to the east side of the building so the waste could be loaded into the main conveyor (Figure 3).

Unfortunately, the conveyor installed by the T&D contractor was not designed to handle the type of material that was being generated by the cleanup. The radium-wastes, typically, were fine grained and cohesive, and tended to clog the grizzly and form bridges in the hopper. The T&D contractor spent considerable time in efforts to keep waste moving through the conveyor. This situation did not lead to significant project delays however, because the interior excavation work was not generating prolific amounts of waste.

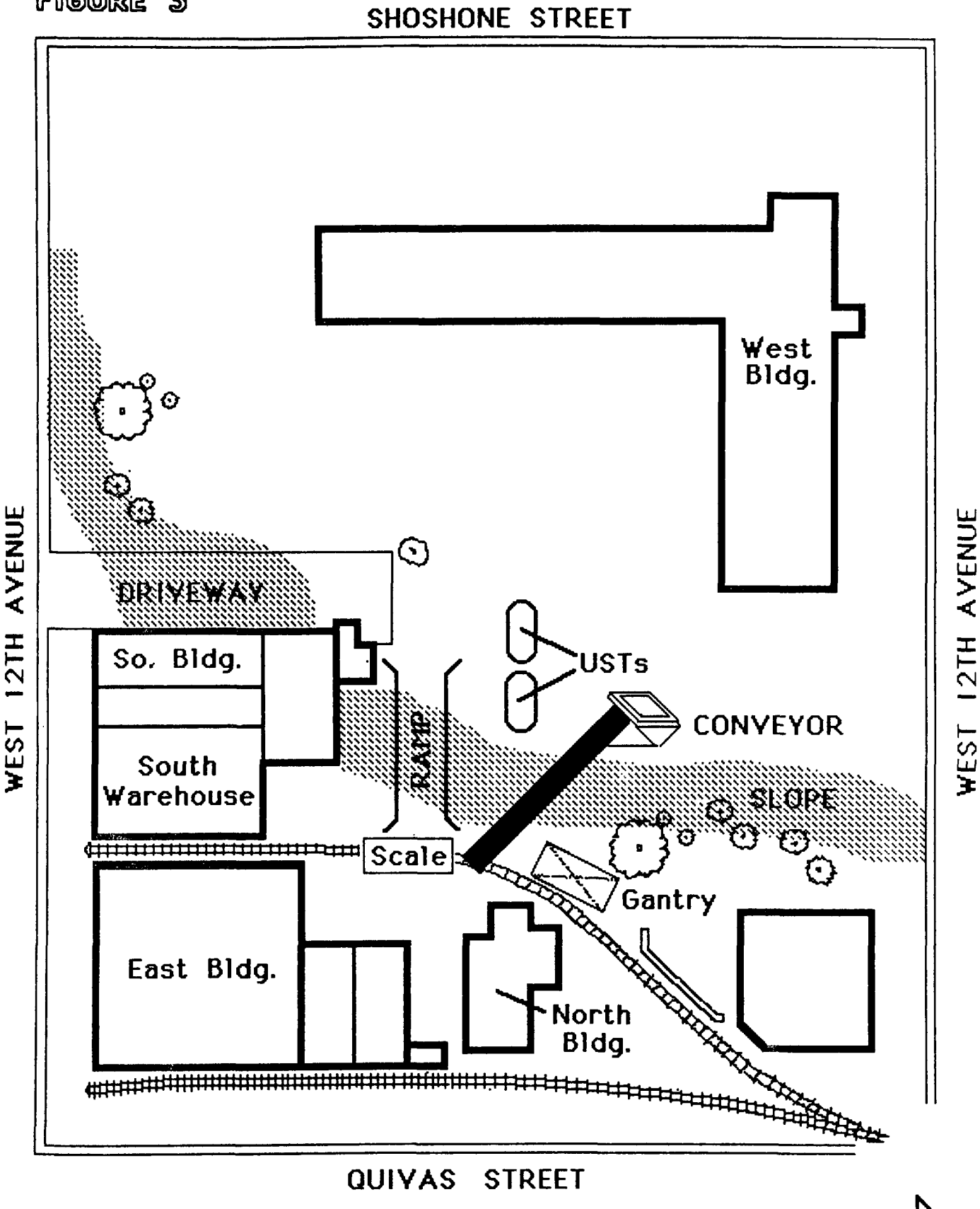
The decontamination and reconstruction of the office and showroom areas proceeded on schedule. However, the contractor was not able to move directly into the warehouse area as planned because the construction of the owners new warehouse was behind schedule. The project was delayed for two

FIGURE 2



OPERABLE UNIT I
DENVER RADIUM SITE

FIGURE 3



OPERABLE UNIT I
DENVER RADIUM SITE

weeks as the owner completed the new building and moved his inventory. Once remedial action started in the warehouse, contamination ran 5 to 6 feet deeper than originally assessed. A total of 2,070 tons of radium-contaminated soils and debris had been removed from the warehouse by the time it was ready for the final verification survey.

PHASE C

The final phase of the cleanup involved the dislocation of three separate businesses and the demolition and reconstruction of 11,800 square feet of office and warehouse space. The first area to be decontaminated in this phase of the project was the exterior area immediately west of the south building (Figure 2). building. The contamination in this area ran more than fifteen feet deep and required the removal of a septic tank that serviced the building. It was known during the design effort that the septic tank would need to be removed. The Denver Building Department would not allow the septic tank to be replaced so it was necessary to design a hookup to the city sewer system.

During the removal of the septic system, two highly deteriorated objects, suspected of being transformers, were discovered inside the tank. The transformers were placed in sealed 55-gallon drums and turned over to the property owner for proper disposal. The discovery of transformers prompted the collection of samples to be analyzed for non-radiologic contamination to assess the potential of encountering mixed (radiologic/hazardous) waste. Two soil samples were found to contain PCBs in the 5 to 10 ppm range, however this did not pose a problem since the disposal facility can accept PCBs up to a concentration of 50 parts per million.

Once the decontamination of the area west of the metal fabrication building was complete, the excavation work moved to the open area in the center of the site. The most radioactive materials at the site were encountered in this area. Approximately 20,000 tons of soil and debris were removed from this portion of the OU, and activity levels between 600 and 1000 pCi/g were common. Gamma exposure measurements in the excavation ran as high as 10 milliroentgens/hour and beta radiation as high as 30 milliroentgens/hour. Contamination extended between 5 and 10 feet deep and was overlain by 2 to 3 feet of clean material which was stripped off and stored on site to be used as backfill.

The first week of this exterior excavation work proceeded slowly due to clogging of the conveyor. After experimenting with a number of methods designed to eliminate the clogging (various vibrating devices), it was decided to take the low technology approach of building an earth ramp up to the track level (Figure 3) and abandon the use of the conveyor altogether. The ramp was steep and there was concern that snow storms would render it too slippery for the front-end loaders, but thanks to an unusually mild winter this never became a problem.

Concurrent with this exterior work, EPA's contractor initiated cleanup activities in the hardware fabrication building (east building, Figure 2). The assessment data indicated that the radium contamination was present beneath the office portion of the building. Boreholes were drilled in the office area during the remedial investigation and remedial design. Augur refusal was experienced in each hole at a depth of about three feet. Given that the current office was at dock level, it was assumed that another floor existed three feet below the present one and that contaminated material was unwittingly used as fill when the office was constructed to its current configuration. Due to the age of the building (built in approximately 1900 as part of a brewery) no drawings could be located to confirm this.

Seven office workers were relocated into a trailer (Figure 2) so the floor could be taken up and the underlying contamination removed. The excavation contractor encountered a layer of brick rubble at a depth of three feet, but the radium contamination continued to a depth of eight feet. Fortunately, the load-bearing columns in the building were setting upon whiskey-barrel caissons that

extended beyond the depth of the contamination. In total, 797 tons of contamination were removed from the interior of the east building.

While reconstruction was taking place in the east building, remedial action began in the sheet-metal assembly building (south building, Figure 2). This building consisted of a two-story structure that existed at the time of radium processing, and two additions that were built atop deposits of radium contamination. The two-story building and the adjoining addition were occupied by a sheet-metal assembly business, while the south warehouse was leased by a concert promoter who used the space to store staging equipment. EPA's original plan was to relocate the concert promoter to an off-site warehouse and move the part of the sheet-metal assembly operation into the south warehouse while the middle section of the building was being decontaminated and reconstructed, and then move the metals operation back to its original location so the south warehouse could be remediated. Fortunately for EPA, the concert promoter was looking for an excuse to break his lease and moved out prior to the start of the cleanup.

A large opening was cut in the cinder block wall that separated the middle addition from the south warehouse to facilitate the relocation of the large metal shears and presses. Approximately 232 tons of radium waste were excavated and shipped to the disposal facility during the decontamination of the south building.

During the reconstruction of the south warehouse, remedial action continued in the area adjacent to the rail spur and on the grave marker company property (north building, Figure 2). Small deposits of radium contamination that were present in the parking area east of the north building were removed using a skip loader and placing the waste into 1-ton cargo bags suspended from a forklift. The cargo bags were subsequently transferred to a gondola. As this last stage of the cleanup progressed, it became necessary to remove sections of the rail spur so that underlying contamination could be excavated. Pulling up the rail spur limited the number of gondolas that could be brought to the site per day from three to two to one.

At the time of publication, EPA's contractor had just finished demolishing an addition to the north building and had removed the last deposit of radium contamination at the site. The original design planned for partial undermining of the addition because assessment data indicated that contamination only extended two feet beneath the structure. However, during remedial action it was discovered that the contamination was more extensive, and the poor condition of the building's floor slab made it too dangerous to continue the undermining operation.

SUMMARY

Remedial construction work at OU I of the Denver Radium Site was performed in three phases. The first phase involved the excavation and disposal of 2,515 tons of radium-contaminated soils and debris and lasted eleven weeks. The second phase of the cleanup was conducted over a period of 7 months and resulted in the excavation and disposal of 2,644 tons of radium contaminated soil and debris. The third and final phase began on June 6, 1990. The site was verified as being free of radiologic contamination on April 19, 1991, and reconstruction of the site will be complete in June of 1991.

Approximately 32,500 tons of radium waste were excavated and shipped to the permanent disposal facility during the three phases of the cleanup (final tonnage figures were not available a time of publication). A total of 301 gondolas and 201 truck-mounted, bi-modal containers were loaded and shipped from OU I in the period between October 1989 and April 1991. The phasing of the remedial action resulted in the successful decontamination of the OU while minimizing the impact that the cleanup operations had on the six businesses that operate on site and the approximately 110 people that they employ.

Streamlining Remedial Design Activities at the Department of Energy's Monticello Mill Tailings NPL Site[1]

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INTRODUCTION

Purpose of this Paper

The Monticello Mill Tailings Site is located in San Juan County, Utah, within the city of Monticello (Figure 1). Mill tailings and associated contaminated material remain on the millsite as a result of uranium and vanadium milling operations. A Federal Facility Section 120 Agreement with the U.S. Environmental Protection Agency (EPA) and the State of Utah, pursuant to the Superfund Amendments and Reauthorization Act of 1986, became effective on February 24, 1989. As stated in the Agreement, the U.S. Department of Energy (DOE) is the responsible party with respect to present and past releases at the millsite. Responsibility for oversight of activities performed under the Federal Facility Agreement will be shared by the Environmental Protection Agency and the State of Utah. A Hazard Ranking System score for the millsite resulted in the inclusion of the Monticello Mill Tailings Site on the Environmental Protection Agency's National Priorities List on November 16, 1989.

The Record of Decision for the Monticello Mill Tailings Site was completed on September 20, 1990.

This action initiated the requirement of the Superfund Amendments and Reauthorization Act of 1986, Section 120, for federal facilities to commence substantial, continuous physical on-site remedial action within 15 months of the completion of the Record of Decision.

The 15-month requirement made it necessary for the Department of Energy to develop a remedial design and implement remedial action within the stipulated timeframe. This had to be accomplished within the framework of the Federal Facility Agreement that stipulated additional timeframes for

[1]Work performed under the auspices of the U.S. Department of Energy, DOE Contract No. DE-AC07-86ID12584.

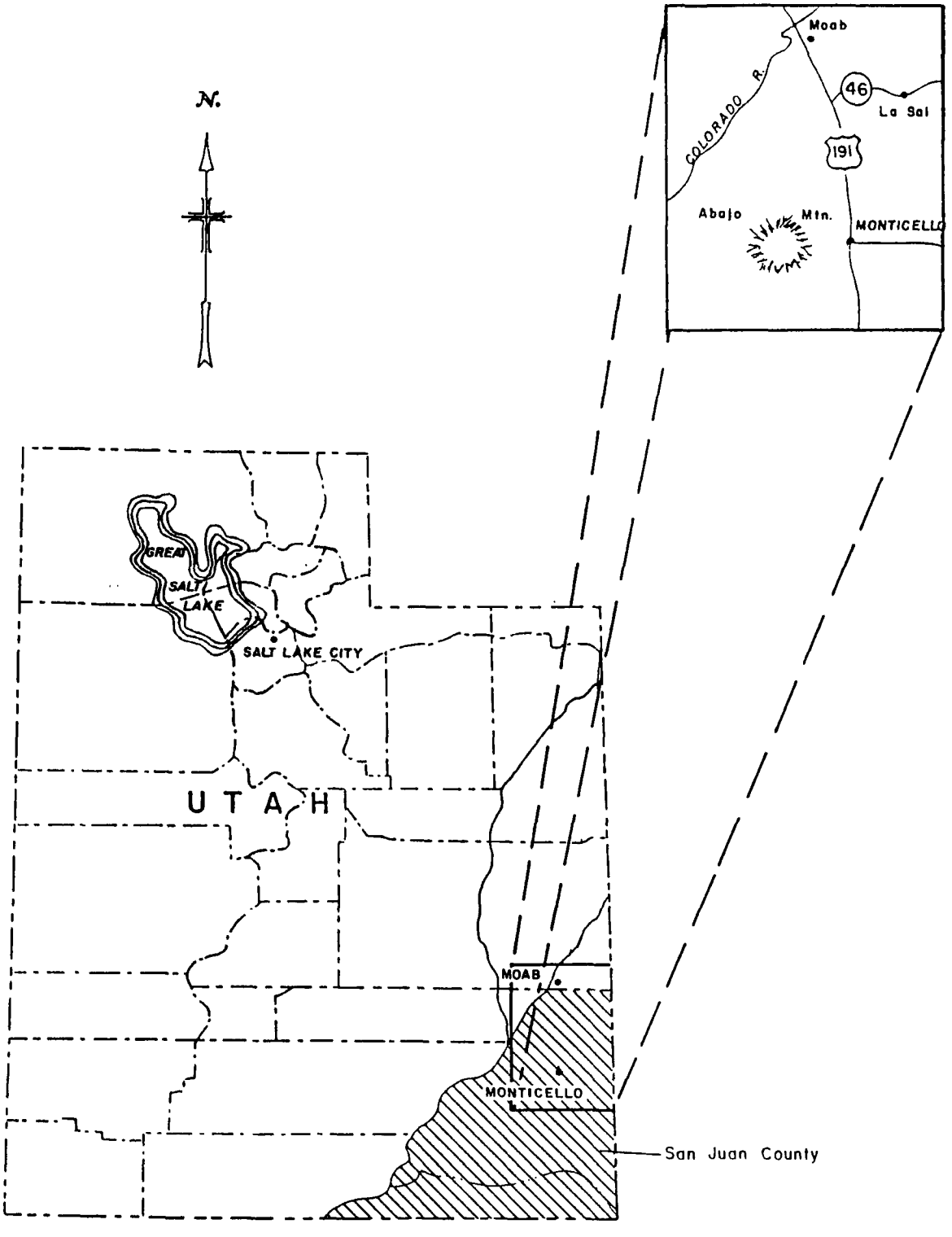

Figure 1. Monticello, Utah, Regional Location Map

review and approval of remedial design documents by the Environmental Protection Agency and the State of Utah prior to their implementation. It became imperative for the Department of Energy to develop a streamlined approach for project implementation to meet the 15-month requirement, in addition to the requirements of the Federal Facility Agreement.

This paper presents the process used by the Department of Energy to develop the plan that was implemented to meet the 15-month requirement, and the implementation plan. The implementation plan had to meet the project objectives discussed in the following section.

Project Objectives

The Monticello Remedial Action Project has the following project objectives:

- Develop a design for the remediation of the Monticello Mill Tailings Site that demonstrates compliance with applicable and relevant or appropriate requirements established in the Record of Decision,
- Develop a schedule that allows for review and concurrence of the remedial design as required by the Federal Facility Agreement,
- Develop a plan for implementation of the remedial design that allows for the start of remedial action within the 15-month timeframe.

These objectives must be met for successful implementation of the Monticello Remedial Action Project.

BACKGROUND

Project Scope

Remediation activities for the Monticello Mill Tailings Site require the removal of an estimated 1.9 million cubic yards of uranium and vanadium mill tailings to an on-site repository. Most of the tailings are contained in tailings piles on the millsite; however, tailings were transported by wind and surface water to properties peripheral to the millsite. The plan for removal of the tailings will be addressed in the remedial action design. This design must demonstrate that compliance with applicable and relevant or appropriate requirements will be achieved.

Site Description

The Monticello Mill Tailings Site includes the millsite and peripheral properties. The Department of Energy owns the millsite, a 78-acre tract within the city of Monticello (see Figure 2). An estimated 1.4 million cubic yards of mill tailings are present in the tailings piles, and an estimated additional 100,000 cubic yards of material are present on other areas of the millsite.

During the period of mill operation, private land to the north and south of the existing site was leased for the stockpiling of ore. The former ore-stockpile areas and areas contaminated by airborne-tailings particulate matter or surface-water transported contaminants cover approximately 300 acres around the millsite and contain an estimated 300,000 cubic yards of peripheral property material to be remediated (Figure 3).

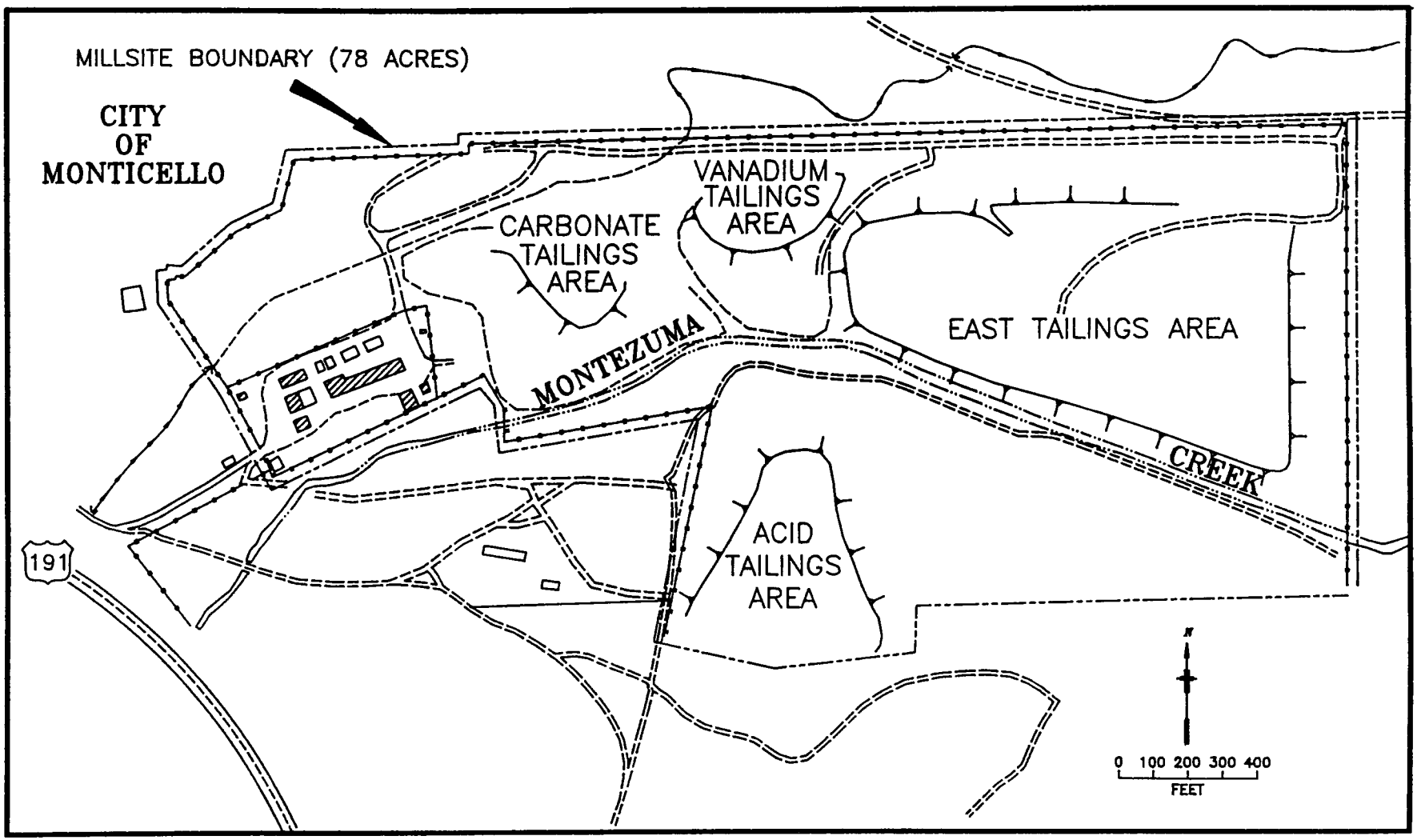

Figure 2. Monticello Millsite Plan

An additional 100,000 cubic yards of contamination is estimated to exist on the Monticello Vicinity Properties (Figure 3). This material consists of both airborne-tailings particulate matter and material that was used as fill or construction material on the properties. The Monticello Vicinity Properties Project was listed on the National Priorities List in 1986 and is being remediated pursuant to a Record of Decision dated September 1989.

The tailings piles are located within the floodplain of Montezuma Creek. They are also partially in contact with a shallow alluvial aquifer underlying the site. This alluvial aquifer is not presently used as a drinking-water source; however, it does have a potential for agricultural use. A deeper aquifer, known as the Burro Canyon aquifer, is a drinking-water supply. Analyses of samples from monitoring wells in the Burro Canyon aquifer show no evidence of contamination. Two aquitards, the Mancos Shale and part of the Dakota Sandstone, separate the Burro Canyon aquifer from the overlying alluvial aquifer under most of the millsite.

Montezuma Creek, which flows through the millsite, is a small perennial stream. Low-flow conditions prevail in the late summer, fall, and winter months. Within the project area, base flow in Montezuma Creek is maintained year-round by ground-water discharge from the alluvial aquifer and by releases from Monticello Reservoir, located approximately one-mile upstream from the millsite.

Project Description

History — The Atomic Energy Commission bought the Monticello milling operation in 1948. Uranium milling commenced in September 1949 and continued until 1960, when the mill was permanently closed. Part of the land was transferred to the Bureau of Land Management; the remaining parts of the site have remained under the control of the Atomic Energy Commission and its successor agencies, the U.S. Energy Research and Development Administration and the Department Energy. The land transferred to the Bureau of Land Management was recently returned to the Department of Energy.

In the summer of 1961, the Atomic Energy Commission began to regrade, stabilize, and vegetate the tailings piles. The plant was dismantled and excessed by the end of 1964. Some of the plant was buried on the millsite. Photographs suggest that contaminated soil was used as fill material to partially bury the mill foundations.

The Department of Energy, under the authority of the Atomic Energy Act, initiated the Surplus Facility Management Program in 1978 to ensure safe caretaking and decommissioning of government facilities. In 1980, the millsite was accepted into the Surplus Facility Management Program and the Monticello Remedial Action Project was established. In February 1989, the Federal Facility Agreement established that the activities at the Monticello Mill Tailings Site must comply with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986. In February 1990, the Department of Energy completed the Remedial Investigation/Feasibility Study-Environmental Assessment for the millsite. The Monticello Mill Tailings Site Declaration for the Record of Decision was approved by all parties in September 1990, establishing the selected remedy.

Selected Remedy — The remedial work at the site has been organized into three operable units (OUs) to facilitate remedial design and remedial action. These are:

- Operable Unit I: Mill Tailings and Millsite Property
- Operable Unit II: Peripheral Properties
- Operable Unit III: Ground Water and Surface Water

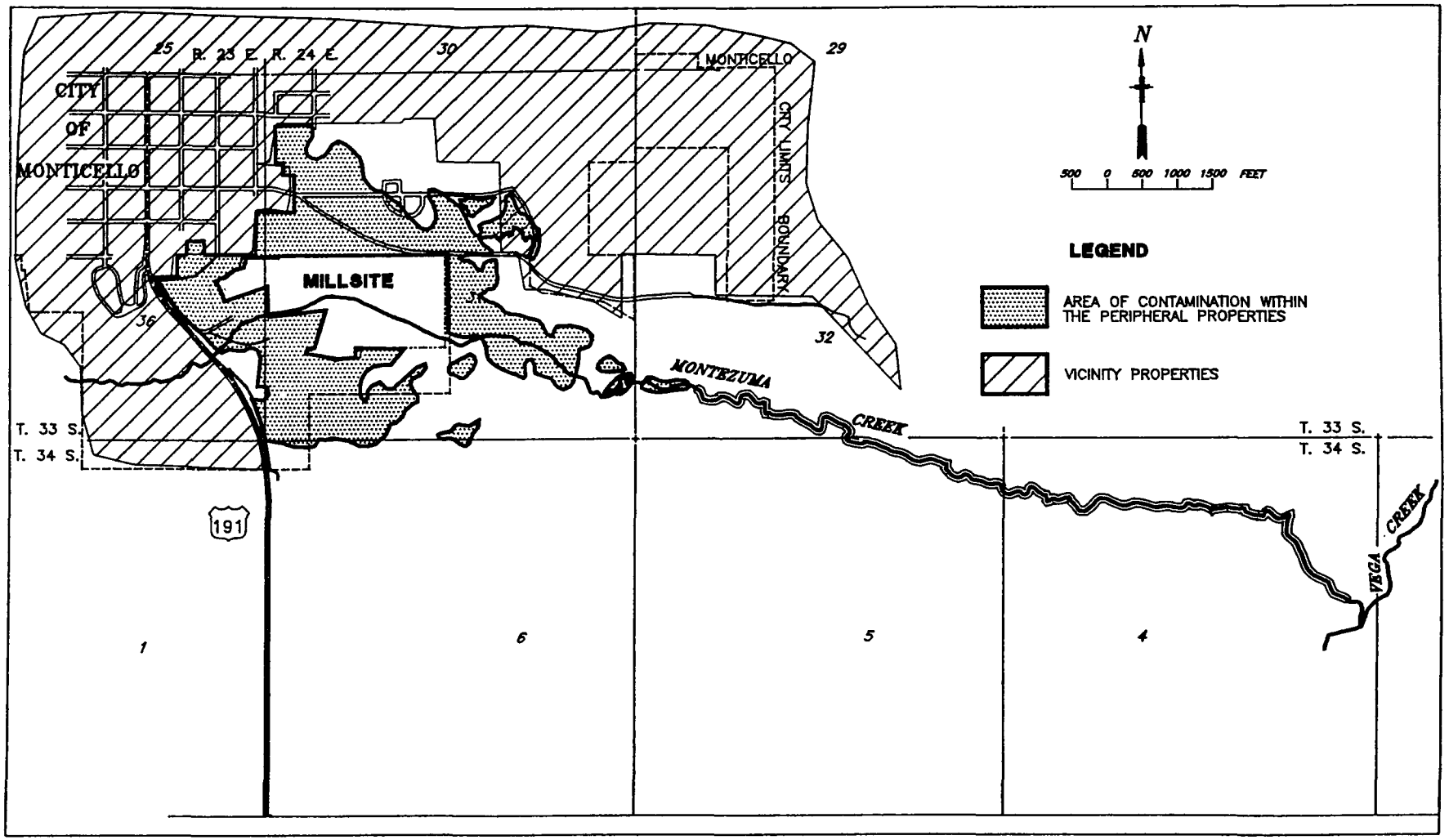

Figure 3. Monticello Vicinity Properties and Area of Contamination Within Peripheral Properties

A separate Record of Decision will be prepared for Operable Unit III because the remedy selected for remediation of ground and surface water depends on the removal of contaminated material from the millsite and from the peripheral properties. The Record of Decision will be completed after the collection of additional surface- and ground-water monitoring data following tailings removal from the millsite and the peripheral properties.

The alternative selected for Operable Unit I involves excavation and removal of contaminated materials to an on-site repository located south of the existing millsite. Removal will be by conventional earthmoving equipment and transport of tailings and other materials will be entirely on site. Dust-control measures and access restrictions will be used to protect public health and the environment during remedial action activities. To control runoff, diversion structures will be built and collected water will be treated as appropriate. Tailings disposal will occur on and contiguous to the existing millsite in a repository covered with a clay and multimedia cap. Design of the repository will comply with 40 CFR 192 performance standards.

The alternative selected for Operable Unit II requires removal of tailings to meet the principal relevant and appropriate standard, 40 CFR 192. Contaminated materials will be transported to an interim storage area and then relocated with the millsite materials to the repository. Removal of contaminated materials will be either by conventional construction techniques or by environmentally sensitive removal techniques. The environmentally sensitive techniques, such as hand excavation or use of high-suction vacuum equipment could be used in areas with mature dense vegetation that would require decades to re-establish the native tree species.

The remedial designs prepared for the selected remedies for Operable Units I and II must demonstrate compliance with applicable and relevant or appropriate requirements identified in the Record of Decision.

DISCUSSION

Approach Used to Develop Plan for Meeting Project Objectives

Development of a plan to meet project objectives was conceived through a Value Engineering (VE) Session. This session was designed to bring representatives from the involved agencies and their contractors together for a "team approach" to project planning. This facilitated session started with a "think tank" approach to identify the issues that needed to be addressed to design and implement the project. This allowed each team member to put their concerns and concepts on the "on the table." As a result of this effort, 48 key issues were identified as important to the development of the project. These key issues were then ranked by the team according to how critical they were to project progress. In addition to identifying critical issues, this phase of the session served to bring the team members up to a comparable level of understanding of the scope of the project.

Once the critical key issues were identified, the VE team worked to resolve the issues. Resolved issues included the need to phase the design and remedial action to meet schedule constraints and the use of "working-level discussion documents" as a mechanism for resolution of regulatory compliance issues. A commitment was made to prepare a Remedial Design Work Plan incorporating the team's concepts on project phasing and identifying the required design documents and their contents. In addition, the VE team made commitments to prepare working-level discussion documents addressing key regulatory issues.

Besides resolving the tangible issues, the VE Session provided the mechanism for building a team approach to project planning. This team-building effort enhanced the ability to communicate between the involved team members, which included government agencies and contractors.

Schedule for Remedial Design and Remedial Action

The schedule for remedial design and remedial action for the Monticello Mill Tailings Site is phased to meet the CERCLA Section 120 requirement for federal facilities to initiate substantial continuous physical on-site remedial action within 15 months after signing the ROD. In addition, the phase approach meets the Environmental Protection Agency's "bias for action" strategy advocated in Office of Solid Waste and Environmental Restoration Directive 9355.5-20, "Guidance on Expediting Remedial Design and Remedial Action." Operable unit I of the project was divided into three general phases: Phase 1 - Site Preparation, Phase 2 - Removal of Tailings and Construction of the Disposal Site, and Phase 3 - Reclamation of the Millsite and Borrow Areas. Figure 4 depicts the schedule for the three phases.

Phase 1 was further divided into three subphases: (1) Millsite Site Preparation, (2) Pre-excavation Activities at the Millsite, and (3) Repository Site Preparation. Design of each subphase requires the preparation of 30 percent and 90 percent design documents. This level of phasing at the onset of the project allows for the preparation of focused design documents and for focused remedial action activities. Preparation of design documents for Phase 1 will require less time than Phases 2 and 3 documents because of less complex engineering and regulatory compliance requirements. This phased approach allows for the implementation of remedial action within the required regulatory timeframes and is also a reasonable approach to construction.

Phase 2 requires the resolution of many significant regulatory requirements, particularly repository design. The preparation and review and approval of the 30 percent and 90 percent design documents for this phase are anticipated to require 2.5 years. If the design for all phases was one document, remedial action could not be implemented within the required regulatory timeframes. Design of Phase 3 activities was split out from the Phase 2 activities to reduce the scope of the Phase 2 design documents.

The schedule identifies the preparation time for design documents and the review-and-approval cycle. The need for an established review and approval process is critical to meet the remedial action schedule. The timeframes shown on the schedule for review, comment resolution, and final concurrence reflect the requirements of the Federal Facility Agreement for the Monticello Remedial Action Project.

The draft Remedial Design Work Plan for the Monticello Mill Tailings Site includes this schedule and describes the contents of the design documents. The Environmental Protection Agency and the State of Utah are currently reviewing the Work Plan. When the Work Plan receives final approval, commitments will be established for document preparation and submittal and for document review and approval to meet the objectives for project scheduling.

Working-Level Discussion Documents

The VE Team identified many complex regulatory issues that are integral to the development of the Phase 2 design. The Department of Energy has prepared working-level discussion documents on each of these issues, providing the technical rationale for DOE's proposed compliance position. The documents that were prepared are listed below:

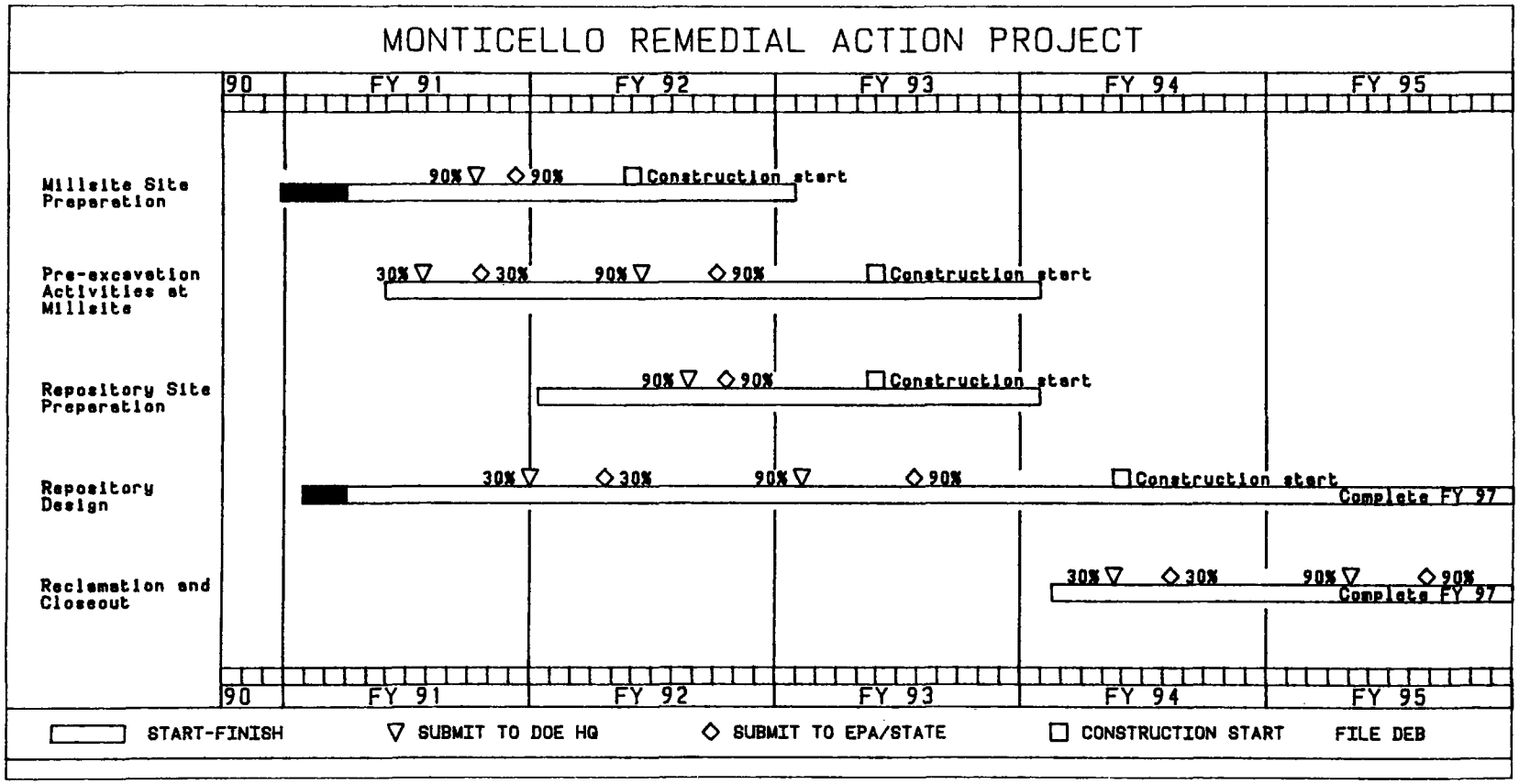

Figure 4. Monticello Remedial Action Project Schedule

- Technical Approach for Designing the Monticello Repository Cover
- Ground Water Compliance Strategy for Engineering Design
- The Use of Engineering Controls in the Disposal of Low Level Radioactive Uranium Mill Tailings
- Point-of-Compliance for Ground-Water Monitoring at the Monticello Repository - Regulatory Interpretation
- Compliance with Applicable or Relevant and Appropriate Requirements for Peripheral Properties
- The Level of Effort Used to Decontaminate Radiologically Contaminated Building Materials and Mill Equipment in the Remedial Design for the Monticello Mill Tailings Site

Each paper evaluates issues that required analysis of site-specific conditions, evaluation of regulatory requirements, and development of a specific position to achieve compliance. The papers were submitted to the Environmental Protection Agency and the State of Utah for review and comment. Meetings were held to discuss the papers and determine further actions necessary to assess compliance.

As a specific example of the use of these documents, the "Point-of-Compliance for Ground-Water Monitoring" document is discussed in further detail. The point-of-compliance (POC) is the location(s) at which a monitoring well(s) must be installed to determine if seepage from the repository has degraded ground-water quality. The requirements of the State of Utah regulations and the Federal regulations are different, and both are applicable and relevant and appropriate requirements.

Determination of the POC is critical to the design of the repository. The design effort must assess changes in ground-water quality as a result of seepage from the repository. The design must demonstrate that changes in ground-water quality will not exceed established ground-water quality criteria at the POC. If this demonstration cannot be made, the design must be modified to provide for additional control of seepage.

An understanding of the geohydrologic setting is critical to the determination of the POC. The geohydrology of the proposed repository site is complex and determination of the location of monitoring wells is not straight forward.

The position presented in this working-level discussion document identified DOE's interpretation of regulatory requirements as they pertained to the current understanding of site-specific conditions. However, uncertainties exist associated with the understanding of the site-specific conditions. Although 69 wells on 200-foot centers were installed on the proposed repository site, location of the POC cannot be agreed upon by the involved regulatory agencies and the Department of Energy.

The discussion document on the POC raised as many questions as it attempted to answer. However, it developed a starting point from which the involved agencies could work together to move forward on establishing the appropriate location(s) of the POC. On the basis of discussions between the Department of Energy, the Environmental Protection Agency and the State of Utah, additional site characterization is being conducted to obtain the data necessary for the determination.

Discussion and resolution of issues through the use of discussion documents focuses the design process. Several directions can often be taken during design to meet design and compliance objectives. The direction that meets regulatory requirements often is not obvious and is subject to professional opinion. A team can use the working-level discussion documents as a mechanism to determine the direction of the design effort. This subsequently results in the preparation of a design that should meet regulatory requirements. Working-level discussion documents also facilitate the review process because the review agencies are familiar with the design issues.

CONCLUSION

The VE Session is a productive tool in development of a project plan. It served to bring the involved government agencies and their contractors together to identify issues significant to the progress of the project and to develop a plan for the resolution of those issues. This team approach also enhanced the communication process between the agencies and their contractors.

The planning approach developed during the VE Session includes a phased schedule necessary to meet the requirement for substantial continuous physical on-site remedial action within 15 months. The schedule identifies focused remedial design packages that could be prepared and implemented within the required timeframe. In addition, the schedule specifies the dates for delivery of documents to the Environmental Protection Agency and the State of Utah and the time for review and approval of the designs. Success of the project depends not only on the submittal of the appropriate designs but also their review. The schedule and description of the contents of the documents to be delivered is included in the Remedial Design Work Plan. Final approval of the Work Plan will establish commitments for document preparation and submittal and for document review and approval.

The use of working-level discussion documents provides a method to focus discussions on regulatory compliance issues and their resolution prior to submittal of design documents. This resolution facilitates preparation of the designs and their review and approval.

ACKNOWLEDGEMENT

Work supported by the U.S. Department of Energy Office of Environmental Restoration and Waste Management at the Grand Junction Projects Office under DOE Contract No. DE-AC07-86ID12584.

CONSTRUCTION OF A KAOLIN CLAY CAP for BURIED NUCLEAR WASTE

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Introduction

A three (3) foot thick RCRA Standard kaolin clay cap was one element of the total structural system used for the permanent closure of a low-level radioactive waste burial ground. Fifty-eight acres at the Department of Energy's (DOE), Mixed Waste Management Facility burial ground facility on the Savannah River Nuclear Plant site were closed during 1989 and 1990. The plant is located near Aiken, South Carolina, with its South boundary adjacent to the Savannah River.

The contaminated waste had been placed from before 1976 until 1986. This waste was classified as low level to intermediate level beta gamma waste. It consists of miscellaneous materials that had been exposed to nuclear radiation, including clothing, building materials, metal vessels, pipes, construction equipment, and fluids such as oil that were mixed with absorbent substances and placed in 55 gallon drums. In some areas, the nuclear wastes were placed in metal boxes, known on site as B25 boxes. These boxes are similar to connex containers.

During operation of the burial ground, most of the wastes had been deposited in a series of parallel trenches which were 20 feet wide by 20 feet deep. Each trench was separated by a 10 to 20 foot berm of natural soil. The B25 boxes were sometimes stacked in an orderly matrix within a trench. However, this was not a standard practice and boxes had been randomly dumped into some trenches. After either the loose mixed waste or the B25 boxes filled the lower 16 feet of a trench, four feet of a sandy silt material was dumped and spread as an initial closure cap. No effort was made to compact the waste in the trench or this soil cap.

It was observed that the soil cap, which had been shaped to shed surface water, was settling and water was beginning to accumulate in the low spots. This was considered undesirable since there was the likelihood of surface water seeping through the cap, becoming contaminated from the nuclear deposits and then percolating downward to the groundwater table. As part of the permanent closure plan, it was decided to densify the nuclear waste within the trenches to reduce future settlement. Densification of the waste by dynamic compaction was the first step before constructing a new impervious kaolin clay cap.

The closure plan required a cap constructed to RCRA regulation standards. To meet these requirements, it was decided to specify a locally available tertiary kaolin clay. From a test program previously conducted, it had been established that the kaolin clay, if properly placed, would have an in-situ permeability of less than 1 x 10 -7 cm/sec.

Design Clay Cap Test Program

Kaolin clay is mined commercially for use in the rubber and paper industries as an inert filler. The majority of that commercial production in the United States is from sedimentary deposits lying along the Georgia/South Carolina "Fall Line." The "Fall Line" is the common name given to the geologic boundary between the Piedmont and Coastal Plain Provinces. Kaolin clay beds of tertiary and cretaceous periods can be found close to the surface in this region.

In the general area of the Savannah River Plant, there are kaolin deposits having only a few feet of overburden. However, overburden stripping depths of 50 ft. are common at many of the operating open pit mines. Because kaolin is found in such plentiful supply locally, it was identified as the material of choice for this project after examining the possible use of natural on-site clays, importing alluvial clay or the use of soil bentonite mixtures.

The design test program examined both construction techniques and resulting cap properties for Tertiary and Cretaceous age kaolin. It became obvious early that the Cretaceous kaolin was a sandier and less plastic material. Therefore, only two test panels were constructed of the Cretaceous clay. These panels proved that it would be very difficult or impossible to achieve the required 1 x 10 -7 cm/sec in-situ permeability with the Cretaceous kaolin. The Cretaceous clay was, therefore, eliminated from consideration. Tertiary clay from three (3) different active mines in the Aiken, South Carolina area was used to construct seven (7) test panels. From each source a panel was constructed at both

standard proctor optimum water content and at two (2) to three (3) percent wet of optimum. The construction technique for these six (6) panels was to add moisture to the clay in a separate conditioning area and then to transport the moisture conditioned clay to the panel for placement and compaction. The seventh panel involved a procedure of moisture conditioning directly on the panel. This eliminated the transport of moisture conditioned clay.

The Tertiary clays had natural water contents in the range of 20 to 25 percent. During the test program, two (2) methods, a stationary Gleason clay shredder and a BROS travelling recycler, were utilized to break down the blocky chunks of clay which were delivered from the mines. This size reduction operation yielded a material having a maximum size of one and one-half inches. The purpose of the size reduction was to enhance the kneading effect of the rollers and to speed the water absorption of the clay by creating more contact surface area. Standard Proctor optimum water content averaged about 25.5 percent. Therefore, the natural material was always dry of optimum, making it necessary to add water in order to achieve the desired placement water content.

The one and one-half inch minus clay was spread in a six (6) to nine (9) inch thick lift and water was added by alternating passes of a water wagon and the BROS recycler. The water wagon did not drive over the clay lift. It was equipped with a nozzle which allowed spraying of the water onto the clay while moving along the side of the conditioning area. The clay was brought up to the desired water content, covered with plastic and allowed to cure overnight. After this moisture conditioning, the clay was picked up and transported to the panel by a CAT 623E elevating, wheel tractor scraper. This is a 365 flywheel horsepower machine which, fully loaded, weighs 129,300 pounds. On the panel, motor graders spread the clay in a uniform lift. Compaction was with a CAT 815B tamping foot soil compactor.

Trautwein type, Sealed Double Ring Infiltrometers (SDRI) were used to test in-situ permeability. A test in each of the kaolin test panels was run for durations of between 98 and 158 days. The results of those permeability tests demonstrated that in-situ permeabilities of less than 1×10^{-7} cm/sec could be expected if the Tertiary kaolin was compacted at water contents two (2) to four (4) percent wet of standard Proctor optimum. The average compaction recorded for the panels was between 94 and 100 percent.

Initial Specifications - Clay Cap Project

The purpose of the project specifications was to insure

that the constructed kaolin clay cap would have a in-situ permeability of less than 1 x 10 -7 cm/sec. Because of the time required to perform in-situ permeability tests, three (3) to five (5) months, another method had to be specified in order to allow cap construction to proceed on a production basis, as over 500,000 tons of clay would have to be conditioned and placed in a time frame of about 18 months. There is a good correlation between placement water content and density, and permeability for clay materials. This is well known and documented in the literature (Lambe, 1955; Lambe and Whitman, 1969; Mitchell et al, 1965; Mitchell and Jaber, 1990). The Design Test program provided the water content and density parameters that could produce the desired permeability end result without the necessity of in-situ permeability testing.

The critical parts of the original project specification concerning the kaolin clay cap are reproduced here using the numbering system of the contract documents.

Specification No. 9513, Section 02290, Earthwork - Clay Closure Cap

2.1 Products

2.1(c) Cretaceous kaolin shall not be used.

2.2(a) Materials - The clay shall be Tertiary kaolin clay with the following properties:

2. Liquid Limit per ASTM D4318-84 shall be between 75% maximum and 55% minimum.

3. Plasticity Index per ASTM D4318-84 shall be between 44% maximum and 26% minimum.

4. Percent passing a number 200 sieve per ASTM D442-63 shall be 90% minimum.

3.0 Execution

3.1(a) Preparation - Clay blocks shall be broken down prior to conditioning to a maximum size of 1-1/2 inch chunks to insure uniform wetting.

3.2 Installation

(c) Conditioning Requirements - Fill Area

1. Moisture conditioning of the kaolin shall be conducted to achieve two to four percent wet of the standard proctor optimum water content.

2. Clay shall be placed in six (6) inch maximum thickness unconditioned, loose lift.

3. Method chosen for conditioning should be capable of penetrating at least two (2) inches below the unconditioned clay lift to ensure all the kaolin is moisture conditioned and stratification between lifts will be minimized. This does not apply to the first clay lift placed.

5. See Appendix V for additional requirements.

(d) Clay Compaction Requirements

1. The kaolin clay shall be compacted to a minimum of 95 percent of standard proctor (ASTM D698-70), maximum dry density, with water content of two (2) to four (4) percent wet of optimum water content.

4. See Appendix V for additional requirements.

3.3 Clay Surface Protection

(a) The fill surface shall be sealed with a drum compactor prior to the placement of the next lift. The scarified surface shall be wetted or dried to adjust the moisture content to the specified placement range.

(e) Until placement of the soil cover, the fill surface shall be kept moistened to prevent shrinkage cracks.

(f) For prolonged delays in placement (weekends, etc.) the surface shall be protected with a six (6) inch layer of unconditioned material or covered with plastic sheets.

3.4 Clay Placement Tolerances

(a) The finished clay cap shall be constructed to the elevations shown on the design drawings and shall be a minimum of 36 inches thick.

(b) A topographical survey of the initial fill* and the top of the clay layer shall be provided by the Subcontractor. The survey shall be based on a 100 ft. minimum grid.

APPENDIX V - REVISION 1, September 23, 1988

Moisture Conditioning of Kaolin: Maximum Loose Lift thickness is limited to six (6) inches due to the observed tendency of the lift to fluff up two (2) to three (3) inches after being recycled at its natural water content.

Kaolin Placement and Compaction: A minimum of 12 passes with a CAT 815B is required. One pass is defined as the drum of the compactor passing over a location. The kaolin should be compacted to a minimum of 95 percent of standard proctor maximum dry density at water contents two (2) to four (4) percent wet of optimum water content.

If the kaolins are moisture conditioned on the existing fill, the lift surface should be leveled with a motor grader after by filling in packed footprints with the loose conditioned clay at the top of the lift prior to placement the next lift.

Quality Control Test Requirements: There will be an initial minimum of six moisture density relations on which to choose the initial water content placement range which is two to four percent wet of average optimum water content.

Once the placement water content range has been determined, the most important soil property to assure uniformity of compaction is water content. One water content is required for every 300 square yards in the conditioning area to assure uniformity of water content prior to placement and compaction. In the placement area, uniformity of compaction is confirmed with in-place nuclear densities with a minimum of one per 500 cubic yards with at least three per day, and at least one per lift. To determine if the average optimum water content is valid, one moisture-density relation is required for each 5000 cubic yards of clay placed.

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*The contoured earthen trench cover of on-site silt upon which the clay was placed.

Attached and part of Appendix V was Table 1, which presents the required testing for kaolin clay cap quality control.

A few items in these initial specifications deserve note. The compaction specification dictated both the method and the result which had to be achieved: 12 passes with a CAT 815B, 95 percent density. The basis for establishing the acceptable water content range was an average of the optimum water contents as determined from the standard proctor curves. The acceptance water content is to be taken in the conditioning area prior to compaction. Density was to be confirmed by the in-place nuclear method. These will be examined in detail in subsequent sections.

Construction Operations

CLAY PULVERIZATION: The construction of a low permeability clay liner involving over 500,000 tons of kaolin is basically a big earthmoving project involving the expected types of equipment; bulldozers, graders, scrapers, water trucks, and compactors. There is one critical difference: on a heavy embankment project, the key objective is maximizing strength and minimizing compression, while in constructing a clay cap the objective is to minimize hydraulic conductivity.

The critical construction operations for cap/liner placement have been identified by research and these were confirmed again by the design test program.

1. The clay must be broken down into small clods to create surface area for water contact so that the material can be remolded into a new homogeneous mass (Elsbury, 1989), specification 3.1(a), 1-1/2 inch maximum clod size.

2. Water must be added and mixed with the clay in order to obtain a uniform moisture content two (2) to four (4) percent above optimum, specification 3.2(3) 1.

3. The moisture conditioned clay should be compacted by a kneading method, Appendix V, CAT 815 requirement.

Recognizing these requirements, several pieces of equipment and construction methods were investigated in the field on a full production basis. The first task was to break down the large clay clods (up to 18" inches) which came from the mine. At the mine, clay excavation and the loading of haul trucks was by hydraulic excavator, a John Deere 892D-LC. The clay was transported to the jobsite by tandem truck, tandem truck pulling a short pup trailer and by trailer trucks. The mining and hauling operations were never a hindrance to production operations. At the burial ground, the clay was dumped either in

Table 1. FIELD AND LABORATORY QUALITY CONTROL TESTING REQUIREMENTS FOR CLAY MATERIAL, FROM APPENDIX V - REV. 1, CONTRACT SPECIFICATIONS, MIXED WASTE MANAGEMENT FACILITY, DOE, SAVANNAH RIVER PLANT

	LAB IDENTIFICATION TEST SERIES INCLUDING:			FIELD QUALITY CONTROL TESTS				
LOCATION (1)	WATER CONTENT ASTM D2216-80 (2)	ATTERBERG LIMITS ASTM D4318-84 (3)	MINUS #200 SIEVE ASTM D1140-54 (4)	MOISTURE DENSITY RELATION ASTM D698-78 (5)	ONE POINT DENSITY (6)	NUCLEAR DENSITY ASTM D2922-81 (7)	WATER CONTENT ASTM D2216-80 (8)	IN-PLACE SAND CONE DENSITY (9)
BORROW PIT								
BEFORE MINING	ONE TEST SERIES FOR EACH MOISTURE-DENSITY RELATION			THREE FROM FACE BEING MINED				
DURING MINING	THREE TEST SERIES WHENEVER CHANGE IN MINING LOCATION							
STOCKPILE AREA	ONE TEST SERIES FOR EACH MOISTURE-DENSITY RELATION			THREE FROM INITIAL 500 TONS DELIVERED			ONE/1000 TONS	
CONDITIONING AREA							ONE/300 SQ YD	
PLACEMENT AREA	ONE TEST SERIES FOR EACH MOISTURE DENSITY RELATION			ONE/5000 CU YD ADJACENT TO IN-PLACE SAND CORE DENSITY	ONE/EACH NUCLEAR DENSITY	ONE/500 CU YD; AT LEAST 3/DAY, AT LEAST 1/DAY		ONE/5000 CU YD ADJACENT TO IN-PLACE NUCLEAR

NOTES:

1. In the conditioning area, microwave water contents on 100 gram minimum clay samples may be used in place of ASTM D2216-80 oven dried water contents.
2. Perform in-place density tests at the base of compactor footprints.
3. Test results shall be filed with owner's representative daily.

the panel construction area or at a stockpile location. The freshly mined clay material had many large chunks.

If the clay was placed directly for cap construction, a CAT D6 bulldozer was used to level the pile and smooth the material into the specified six (6) inch lift. Major size reduction was accomplished during this leveling, as chunks were broken down by the weight and motion of the dozer. The dozer tracks would bridge across low spots and place all contact pressure on the largest chunks; these were the high points causing the bridging. This would crush the largest chunks. After leveling by the dozer, the material could be classified as six (6) inch minus; therefore, further size reduction was still necessary. A Howard rotavator accomplished the final size reduction during the early clay cap construction. A rotavator is nothing more than an oversized garden tiller. It has thirteen rows of three tines per row for a total of 39 tines. The ones used on this project were eight (8) feet in width, pulled by 140 HP farm tractors, and powered by the tractor's PTO. The tractors could pull through natural water content clay for pulverization work at a speed of 175 ft/min. Clod reduction was accomplished by mechanical pulverization.

A Gleason Shredder was used for a limited time on the project. This same type machine had been tried during the design test program. The shredder is a revolving blade with teeth; it cuts the clay into the desired size in the same manner as a meat grinder. It did a very good job of producing a material within the desired size range. The drawback and primary reason it was not used for mass production was the shredder's pass through tonnage limitation. With the blade set to operate at the project's required 1-1/2 inch maximum size limit, pass through production was only 140 tons per hour.

The shredder added extra material handling steps to the production process. For a short duration, the clay was loaded directly into the shredder during excavation. The shredded clay fell onto a fast revolving belt which would sling the clay chips into a stockpile. A wheel loader was then used to load the trucks for the haul to the jobsite. The other option was not to change the mining and hauling operation of the raw clay, but to build a stockpile at the burial ground, and use a loader to feed the shredder from that stockpile. The shredder would then create a second stockpile of sized material from which self-loading scrapers would haul to the panels. This method of operation was tried for about one month.

The final method examined and the one used throughout most of the clay cap construction was mechanical pulverization by a CAT SS-250 soil stabilizer. As with the rotavators, the pulverization was accomplished after the raw clay had been

leveled into a six (6) inch lift by the dozer. The SS-250 had a working speed of 88 ft/min, or about half that of the farm tractor-pulled rotavators, but the required pulverization could be accomplished in half the number of passes. There are twice the number of tines on the SS-250, thirteen rows of six (6) tines per row. Experiments with both up-cutting and down-cutting rotors were tried over the course of the project. The best results were obtained using chopper tines and up-cut rotation with the rear door closed. Maximum clod size would increase as the door opening was increased. Typically, two (2) passes with the SS-250 were necessary to bring the clay down to the 1-1/2 inch maximum size requirement. However, in some locations three (3) passes were necessary. This was usually caused by the fact that when operating uphill, the operator would have to increase the rear door opening.

On a normal stabilization project, the SS-250 will operate at average propel pressures of about 2250 psi. Working the kaolin on a flat surface up-cut mode, the propel pressure was 3500 psi. While on a seven (7) percent grade, the pressure would go up to 3700 psi. The machine has a pressure override value which is set at 3700 psi; therefore, when going uphill, the operator would have to increase the opening of the rear door to avoid stalling. The down-cut mode would have been easier on the machine, only 2200 psi uphill, but pulverization was not as good and the clay would stick to the rear door causing other problems. In fact, even operating up-cut, severe pressure was placed on the rear door. The rear door cylinder had an average life of only 850 operating hours.

MOISTURE CONDITIONING: Once the clay had been processed so that no individual clods were larger than 1-1/2 inch, moisture conditioning could begin. The first efforts were crude, simply having a standard water truck make multiple passes over the pulverized clay until it became too slick for passage. Then farm tractor rotavators would make a couple of passes to mix the clay and water. After this mixing, the water truck could make about two (2) more passes and then it became a sequence operation of rotavator pass, water truck pass. It did not take long to realize that multiple water truck passes without mixing passes by the rotavator made for a situation where the water collected in the tire ruts and those areas forever afterwards had water contents higher than the mass of the panel. Another problem with standard water trucks was that more water came out at the middle of the spray bar where the pipe from the tank connected than at the ends of the bar.

To get uniform coverage along the spray bar, a special bar and pumping system was placed on each water truck. The spray bar was a continuous loop system on these trucks and there was a circulating pump system so that the pressure at each nozzle was

approximately the same. This solved the problem of uniform coverage from the bar. To eliminate the problem of water collecting in the ruts, it became standard operating procedure to follow directly behind the water truck with either the rotavator or the SS-250 stabilizer. By following directly, it is meant that the truck and mixer operated in tandem usually with no more than 10 feet of clear distance.

One other method of introducing the water was experimented with for a few days. The SS-250 has an internal water spray system. Water is introduced by a hose connection on one side of the machine. A water truck must, therefore, drive alongside the stabilizer, with the two machines connected by hose. This internal SS-250 system exhibited the same problem as the spray bar, the nozzles closest to the point where the water was introduced put out more water than the nozzles on the end. Uniform wetting could not be achieved.

The adopted production procedure was: (a) use the special water trucks to add water with the rotavator following directly behind for the early passes; (b) as the water content of the clay increased, a point was reached where the farm tractor and rotavator did not have the necessary power to thoroughly mix the clay, at that point, the SS-250 would take over behind the water truck; (c) once all the water had been added, the SS-250 stabilizer would make two (2) additional passes to complete the mixing.

From moisture content tests of the pulverized clay, the amount of water which had to be added could be calculated. All of the water trucks had metering systems. The problem was not figuring how much water to add in order to reach the specified moisture content, but estimating the amount of evaporation which would take place in the time interval required to add the water and complete compaction. During a summer day shift, the amount of extra conditioning water necessary to make up for evaporation loss was about 3.2 gal/ton. Operations at night required only 0.8 gal/ton extra. Other factors which had to be considered were direct sunshine and wind.

COMPACTION: A CAT 825 tamping foot compactor was tried on the project. Considering the drum width and assuming one inch of contact surface along that width, the contact pressure of the CAT 825 is about 1.4 times that of the CAT 815. With the kaolin conditioned to two (2) percent wet of optimum or higher, the feet of the CAT 825 would be pushed completely down into the moisture conditioned clay. The clay would then stick to the drum and with the forward motion of the compactor, the newly placed upper lift would be pulled up and torn away from the previous lift. Operations with the CAT 825 were, therefore, not satisfactory and all further compaction was with the 44,175

lb., CAT 815 compactor.

A 10 -7 Cm/Sec Product

The desired product was a kaolin clay cap which would have an in-situ permeability of less than 1 x 10 -7 cm/sec. Quality control, testing and acceptance of the in-place clay was by a third party QC organization reporting to the project construction management organization. Neither the construction contractor, the construction manager, or the QC organization could change or even interpret the contract specifications. For a moisture conditioned and compacted panel of clay to be accepted, it had to meet the LETTER of the specifications.

This type of construction quality control/acceptance is to be expected when dealing with nuclear or hazardous materials. But when this situation exists, the design engineer must understand the nature of the materials being handled and limitations in testing precision. The written specifications must be such that every individual part of the construction process is addressed in a realistic manner. No designer can foresee every possible situation, therefore, provisions should be built into the specifications which establish procedures to resolve unique situations.

As an example of the unique situations which can occur during waste projects, density could not be obtained on the initial lifts in one specific area of the burial ground. At first, it was thought that the maximum allowable lift thickness had been exceeded and that was causing the problem. There was, also, some question as to the quality of the clay. The kaolin was removed and fresh clay was brought from the mine. The results were no better; density was not achieved. It should be remembered that Appendix V had specified the use of in-place nuclear densities to confirm compaction, Table 1, Column 7. Finally, special sensitive radiation testing equipment was used to check the background readings from the buried waste. In this particular area, the background radiation was slightly greater and it was affecting the nuclear density meters. This was only noticeable during testing of the first one or two lifts. The testing in this area had to be changed to the sand cone procedure for all density tests.

Compaction difficulties were encountered because of the double specification, method and result. At the higher water contents, 12 passes with the CAT 815 compactor caused an over-rolling situation in terms of dry density. The density actually began to decrease after about 8 passes. Specifications should never be written in this manner. If density is the critical parameter, that is what the designer should require. In this

case, density was being used because of its correlation to permeability from the test program. However, in the case of liners, where clay soils are compacted wet of optimum, density alone may not be a good gauge of permeability. It has been found (Mitchell et al, 1965) that even though the dry density of a compacted soil did not measurably increase with the application of more compactive energy, the hydraulic conductivity could be lower by a factor as high as 100. This can be attributed to the kneading action of the additional compactive effort.

When dealing with soils, more passes are not always better in terms of dry density but they can lower the permeability. This is a critical decision in establishing cap/liner specifications and that decision must be made by the design engineer, it cannot be imposed on the construction contractor by an impossible double specification. On this particular project, the decision was made to reduce the required number of passes to eight, Appendix V - Rev. 13, and to change the minimum dry density of 93 percent if the water content was greater than four percent wet of representative optimum, 3.2(d)1.e, Rev, 13,

The required six (6) inch maximum lift thickness, specification 3.2(c)2., caused problems initially. When a six (6) inch kaolin clay lift was laid down as the first lift on top of the trench cover, the kaolin would become contaminated with the red sandy silt from below during the mixing and compaction operations. The tines of the rotavators or the SS-250 would cut into the lower layer where the kaolin lift was not the maximum six (6) inches. The feet of the CAT 815 would puncture through the kaolin and pull the red silt up into the white clay. Because of the color difference between the two materials, contamination was always easily discerned. The specification did not allow for a thicker lift, and full mixing and compaction were required. Mixing could have been achieved on top of the other panels and the condition material hauled to the initial placement panel as was done during the design test program. Such a procedure would not have solved the compaction problem. An alternate would have been to compact the initial lift with a smooth drum roller, but that would have eliminated the important kneading action during compaction. The adopted solution was to allow a ten (10) inch initial lift, to condition that lift to a depth of eight (8) inches and to retain the use of the tamping foot roller, Rev. 12, Specification 3.2(c)6.

The Clay Closure Cap specifications addressed the preparation, placement and compaction procedures for construction and specified the minimum required quality control testing for each stage of the work, Table 1. In Appendix V, Rev. 1, under Quality Control Test Requirements, the water content placement range was spelled out as "....two to four

percent wet of average optimum water content." Procedures for moisture conditioning prior to compaction were specified. Water content tests were required in the placement area. Only density tests and standard Proctor or one point compaction tests were required in the placement area. The density tests were for evaluation of the uniformity of compaction, while the Proctor or one-point compaction tests were to confirm the validity of the assumed optimum water content.

It was very clear that the intent of the initial specifications was to establish the uniformity of the water content prior to compaction and to check only the density after compaction. If confirmation of the uniformity of the water content after compaction was intended, water content tests would have been required in the placement area. This is not an unusual procedure. Daniel (1990) uses almost the exact same statement, as contained in Appendix V, when he addresses water content quality control for compacted soil liners. "The soil must be within the proper range of water content prior to compaction." Whereas, the Appendix V statement is "One water content is required for every 300 square yards in the conditioning area to assure uniformity of water content prior to placement and compaction."

The specifications required six Proctor compaction tests, three at the borrow area and three at the stockpile, for selection of an initial average optimum water content and an initial moisture content placement range, which was to be two to four percent wet of the average optimum water content. Additional standard Proctor compaction tests were required after compaction "to determine if the average optimum water content is valid." However, when a test did not confirm the validity of the average, it was was not clear how the information was to be used. Should it alter the acceptable water content range for the specific section being evaluated or should it alter the average optimum water content and placement range for future compacted sections or both? Also, a one-point compaction test was required in conjunction with each nuclear density test on the compacted fill. The purpose of these tests was not stated in the specifications, but their primary function would be to provide additional estimates of the optimum water content and maximum compacted dry density of the compacted fill.

The quality control procedures initially employed by the inspectors deviated from the specifications in at least one very significant aspect. The water content measurements during conditioning were designated "for information only," and a second set of "official" water content tests were made after compaction. Water contents were reported to the nearest 0.1 percent, and acceptance of a specific compacted section required all "official" water contents to be 1.5 to 4.5 percent wet of

the predetermined average optimum water content, which presumably was based on one or more standard Proctor compaction tests.

Variability of Kaolin Clay

COMPACTED TEST PANELS: During the Design-Clay Cap Test Program, three test panels B1, B2, and B3 had been constructed using clay from the same source as was used for project construction. The variability of the test results for those panels was particularly relevant to the interpretation of the earthwork specifications. The average optimum water content from standard Proctor tests of the kaolin was 26.8 percent, but the individual test results varied from 24.2 to 29.2 percent. At the same time the water contents of the compacted fill varied from 26.4 to 32.8 percent, and these values were reported to be from 1.7 to 6.8 percent above their respective optimum water contents. Moreover, the standard deviations of the water contents for each test panel ranged from 1.1 to 1.3 percent, and the standard deviations of the differences between the field water content (w_f) and optimum (w_{opt}) were 1.0 to 1.6 percent.

The significance of the standard deviation is that approximately two thirds of the test results should be expected to be with $\pm$ one standard deviation of the mean value. This means that for test panel B3, for which (w_f - w_{opt}) had a mean of 2.9 percent and a standard deviation of 1.0 percent, only about two thirds of the measured water contents were two to four percent wet of optimum. For the other two panels, the mean values and standard deviations of (w_f - w_{opt}) indicate that significantly less than two thirds of the measured water contents were in the range of two to four percent wet of optimum. It is important to note that all of these test panels satisfied the permeability criteria for the clay cap, Table 2.

CONSTRUCTION TEST DATA: During a one-month period early in the project, more than 50 percent of the clay panels tested were rejected because one or more of the "official" (after compaction) water contents were not within the range of 1.5 to 4.5 percent wet of the established average optimum. In every case, the conformance of the compacted density and water content to specifications was evaluated on the basis of an optimum water content of 25.6 percent and a maximum dry density of 95.9 lb/cu. ft. Approximately 90 percent of the 44 reports showed nuclear moisture and density results in conformance with specifications. Only one case of inadequate density and high water content was found. Four nuclear tests were designated as nonconforming because the water content was less than 1.5 percent wet of the established optimum.

Table 2. SUMMARY OF INFILTROMETER TEST DATA, DESIGN-CLAY CAP TEST PROGRAM
MIXED WASTE MANAGEMENT FACILITY, DOE, SAVANNAH RIVER PLANT

PANEL NO. (1)	KAOLIN CLAY TYPE (2)	START OF TEST (3)	NO. OF TEST DAYS (4)	AVERAGE WATER CONTENT W (%) (5)	AVERAGE $W - W_{opt}$ (%) (6)	AVERAGE % STANDARD PROCTOR COMPACTION (7)	FINAL INFILTRATION RATE (cm/sec x 10-7) (8)	FINAL WETTING FRONT DEPTH (in) (9)	FINAL FIELD PERMEABILITY K(field) (cm/sec x 10-7) (10)	AVG. LAB PERMEABILITY, K(lab) (cm/sec x 10-7) (11)
A1	CYPRUS TERT	10/22/87	134	27.0	-1.3	105	2.3	25.0	1.6	0.81
A2		12/02/87	98	30.6	2.0	100	0.48	25.0	0.32	0.28
B1	DIXIE TERT	10/15/87	141	29.6	3.5	94	0.96	20.5	0.61	0.34
B2		10/28/87	124	30.7	3.6	98	0.85	23.0	0.56	0.25
B3		01/12/88	101	29.4	2.9	98	1.3	28.0	0.91	0.27
C1	HUBER TERT	11/16/87	158	26.8	0.4	103	1.8	27.0	1.2	0.34
C2		11/23/87	106	29.8	2.7	100	0.70	28.0	0.49	0.43
D1	CYPRUS CRET	11/12/87	117	24.6	3.4	98	5.1	28.5	3.6	1.6
D2		12/03/87	141	22.7	2.0	97	6.8	34.0	5.0	1.7

NOTES:

1. All infiltrometer tests performed with a scaled double ring infiltrometer with a 12 foot square outer ring and a 5 foot square inner ring.

2. For all test panels, the final wetting front depth is equal to the total depth of compacted clay fill.

An analysis of the 300 "official" water contents included in this data base showed a mean water content value of 28.6 percent and a standard deviation of 1.5 percent. The mean value was 3.0 percent wet of the established optimum, and, when rounded to the nearest 0.5 percent, 76 percent of the water contents were within the specified range of two to four percent wet of optimum. Thus the compacted fill represented by this data base was at least as uniform as the design test panels.

A plot of the moisture-density data, Fig. 1, from the nuclear density tests shows the test data clustered along a line roughly parallel to and wet of the "line of optimums" from the test panel data. There is evidence in the literature to suggest that this line represents moisture-density conditions of approximately equal permeability.

EFFECT OF KAOLIN NATURAL VARIABILITY: Another important factor was that the specifications, as initially applied, failed to recognize the natural variability of the kaolin. Proctor curves had shown optimum water content values from 24.1 to 27 percent. The chosen average optimum value was 25.6, which in turn set the acceptability limits at between 27.6, plus two, and 29.6, plus four percent. This decision to use the average as a benchmark presents several problems. Consider the case of a batch of clay actually having an optimum of 24.1 percent. To provide the required permeability, the clay would have to be placed at a water content of between 26.1 and 28.1 percent. However, by the written specification, any panels having test below 27.6 would be rejected, this forced unnecessary rework of acceptable clay. Now consider if the clay actually had an optimum of 27 percent. In order to meet the minimum plus two percent criteria, this clay would, as a minimum, have to be placed at a 29 percent water content. In this case, clay which was not even conditioned to plus two percent of its natural optimum would be accepted by the average 27.6 minimum criteria. These facts are diagramed in Fig. 2 based on the project data discussed in the preceding paragraphs.

The correct criteria should look at the relationship between water content and density. Plotting the test point, as in Figures 1 and 2, will prove if the condition clay is acceptable; it must fall within the band of the line of optimums and the saturation line. Recognizing the situation, the clay cap specifications were revised over the course of the project. The revised specifications are presented in the following section. These criteria, which are consistent with the recommendations of Daniel (1990), provide a good guide for future clay cap or liner specifications. The constraints and the capabilities of large scale production oriented construction operations are addressed and the variability of the clay and testing precision are accounted.

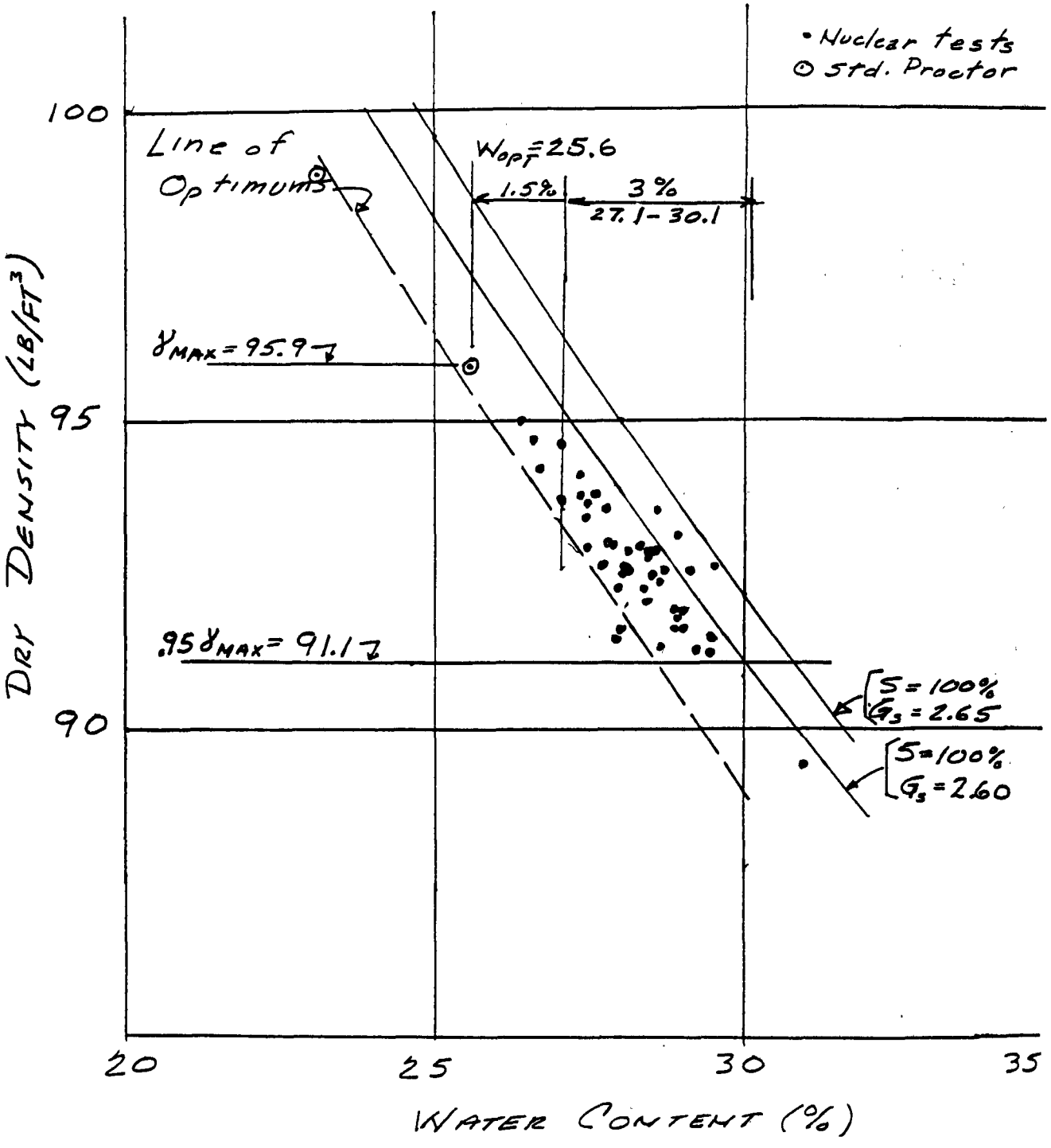

FIG. 1. Moisture-Density Data from Nuclear Density Test during October 1989, Kaolin Clay Cap, Mixed Waste Management Facility, DOE, Savannah River Plant

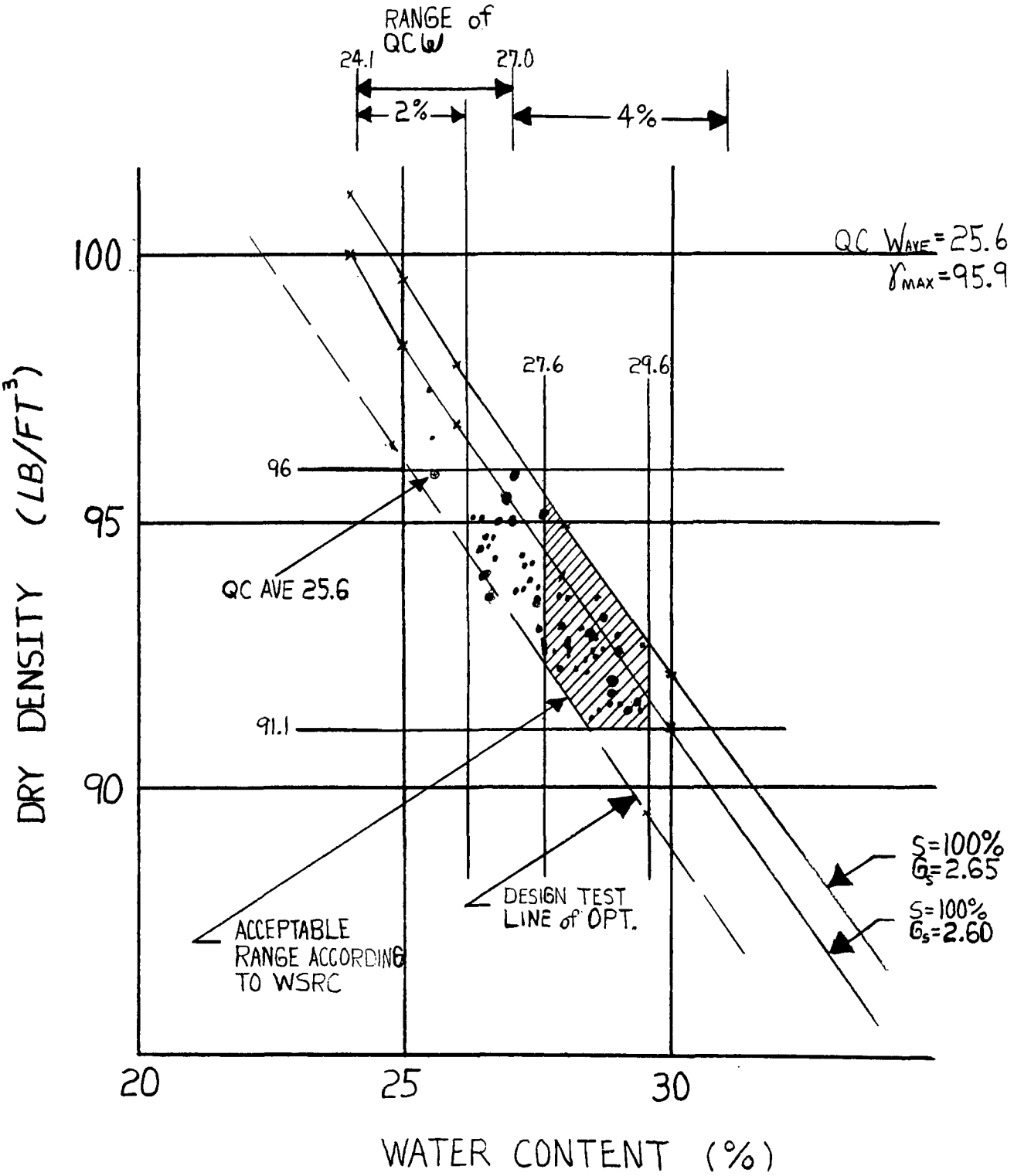

FIG. 2. Initial Specification Acceptance Criteria Moisture-Density Data, Kaolin Clay Cap, Mixed Waste Management Facility, Savannah River Plant

PRECISION OF WATER CONTENT TESTS: The precision of the testing procedures is recognized in the revised specifications. Both optimum and field-compacted water content values are rounded to the nearest half of one percent, 3.2(3)1.a. and h., and variance and retesting procedures are established 3.2(d)1.g., 3.7 and 3.8. More research needs to be performed to address the precision of water content testing of clay materials. During the course of the project, samples were split and separate water content tests were performed on each half. Differences as great as 3.7 percent were noted. The average difference was about 1.8 percent. If the water content values were rounded to the nearest half of a percent, the average difference was about 1.5 percent. A specification, which is strictly enforced, that restricts the water content to a two (2) percent range in combination with a test procedure that has a precision range of 1.5 percentage points causes problems in the field.

Revised Clay Cap Specifications

As the Kaolin clay placement operations progressed, changes were made to the original specifications. The most significant changes, are presented here, and as in the first Project Specification section, the contract numbering system is retained.

3.2 Installation

(c) Conditioning Requirements - Fill Area.

1. Moisture conditioning of the Kaolin shall be conducted so as to achieve the water content requirement, after compaction, as specified in Section 3.2(d). Water content testing after conditioning and prior to compaction shall be for information only.

6. Place initial loose clay lift to a maximum ten (10) inch thickness above the top of the initial fill as defined by the recorded topographical survey and to a thickness not to exceed thirteen (13) inches. The top of the lift shall be consistent in slope with the contract drawings. The clay shall be conditioned to a depth of eight (8) inches or two (2) inches above the top of the initial fill. No nuclear density test will be performed on the initial clay lift. Compaction is to be performed by a sheepsfoot roller. (This entire paragraph was added.)

(d) Clay Moisture and Compaction Requirements.

1. The Kaolin clay shall be compacted to the following minimum compaction and moisture content criteria:

   a. The representative standard proctor optimum water content and maximum dry density that form the basis for clay placement is to be selected by the Customer's Design Engineer. This is based on the Design Engineer's evaluation and judgment of standard Proctor compaction curves, one point dried back compaction tests and the physical condition of the clay at placement water content. The representative optimum moisture content shall be rounded to the nearest 0.5%.

   b. The acceptable average water content range for clay placement is one to six percent wet of the representative optimum water content. However, it is acceptable to have one sample greater than six percent wet of optimum water content.

   c. The acceptable average water content is two to four percent wet of the representative optimum water content. Exclude one allowable sample greater than six percent wet of optimum water content in determining the average water content.

   d. The minimum acceptable dry density for an in-situ density test with a water content between one percent and four percent wet of the representative optimum water content is 95 percent of the representative standard Proctor maximum dry density.

   e. The minimum acceptable dry density for an in-situ density test with a water content greater than four percent wet of the representative optimum water content is 93 percent of the representative standard Proctor maximum dry density.

   f. The number of tests deviating from the acceptable water content range (per Specification 9513, Section 2290, 3.2(d),1, b, c, d, and e) and the resampling guidelines (per Water Content Resampling Guide-

lines, Specification 9513, Section 2290, 3.7 and In-Situ Density Retesting Guidelines, Specification 9513, Section 2290, 3.8), are based on the size of the Subcontractor's average placement areas, i.e., a maximum of 1,400 square yards. If the Subcontractor significantly increases the maximum size of his placement areas the Design Engineer shall be notified for review and redefinition of the guidelines.

g. The Customer's Design Engineer or his approved designee may allow a variance based on engineering judgment for Specification 9513, Section 2290, 3.2(d) moisture content requirements. This variance will provide at Design's* discretion, a means to accept lifts that are technically acceptable but fail to met special moisture content requirements. All variances shall be approved and documented by the Design Engineer or his designee. Design shall reserve the right to reject any or all requests for variances. Design shall submit the variance form with Ebasco Test Report for each lift for which the variance was requested. The Report will indicate that the test for that lift was accepted without meeting the specified moisture content requirements and filed accordingly with the variance approval attached. Lifts that fail to meet Section 2290, 3.2(d) moisture requirements shall be in conformance with Specification 9513, upon approval of a variance by Design.

h. The moisture content test shall be rounded to the nearest 0.5%. See Appendix V. A minimum of ten moisture tests are required per placement area.

i. The nuclear density percent compaction value shall be rounded off to the nearest 0.5%.

6. A one point dried back compaction test shall be obtained (by others) in the third and fifth

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*Design as used here means the design engineering organization for the project.

lift and any other lift as directed by Customer's Design Engineer.

3.7 Water Content Resampling Guidelines (Performed by Others)

(a) Where the water content samples for a clay placement area are not within the acceptable water content range, resampling is permitted. Resampling consists of obtaining two additional samples in the vicinity of a non-conforming tests. The new water content is determined by averaging the two additional test samples and replaces the non-conforming tests.

1. If the water content of one test sample is less than one percent wet of optimum water content, resample in the vicinity of the non-conforming test. If the resample water content is within the acceptable water content range, disregard the non-conforming water content.

2. If the water contents of the two test samples are greater than six percent wet of optimum water content, resample in the vicinity of each non-conforming test. If both resample water contents are within the acceptable water content range, utilize both to determine if the placement area is in conformance. If one of the two resamples falls within the acceptable water content range, the non-conforming resample shall be disregarded. If both resample water contents are outside of the acceptable water content range, the placement area is in non-conformance.

3.8 In-Situ Density Retesting Guidelines (Performed by Others)

(a) Where the water content of the in-situ density test sample for a clay placement area is less than one percent wet of optimum water content or the water content of the in-situ density test sample is greater than six percent wet of optimum water content and the dry density does not meet the minimum requirements, an in-situ density test is permitted.

1. If the water content of the in-situ density

test is less than one percent wet of optimum water content, retest within the vicinity of the original test. If the water content for the retest is within the acceptable water content range, disregard the initial in-situ density test.

2. If the water content of the in-situ density test or retest is greater than six percent wet of optimum water content, no retesting is necessary if the dry density meets the minimum requirement.

3. If the water content of the in-situ density test is greater than six percent wet of optimum water content and the dry density is less than the minimum requirement, retest within the vicinity of the original test. If the dry density of the retest meets the minimum requirement, disregard the non-conforming test.

4. If water content of the in-situ density test is within the acceptable range and the test fails the dry density criteria, the Subcontractor shall continue compaction efforts, until the material meets the dry density criteria.

APPENDIX V - REVISION 13, August 24, 1990

Kaolin Placement and Compaction: A minimum of 8 passes with a CAT 815 sheepsfoot compactor or engineer-approved alternate method is required. Additional passes may be required to satisfy density requirements. The CAT 825 sheepsfoot compactor is not an engineer-approved alternate method. One pass is defined as a compactor drum passing over a location one time. The speed of the CAT 815 shall be less than 5 miles per hour. The front and rear drums of the CAT 815 must be offset from each other so that the feet do not fall within the same imprint or along the same parallel track. The kaolins shall be compacted to the minimum compaction and water content criteria required by Specification 9513, Section 2290, 3.2(d). An engineer-approved single drum sheepsfoot compactor is allowed for ditch and tightly spaced clay panel applications. The Ingersoll-Rand SD100F is considered an engineer-approved single drum sheepsfoot compactor. Specified density requirements shall be met using the smaller

compactors.

Quality Control Test Requirements: Once the placement water content range has been determined, the most important soil property to assure uniformity of compaction is water content. Therefore, one water content is required for each 100 tons of clay delivered to the stockpile area to determine the average water content of the clay as delivered. One water content is required for every 300 square yards in the conditioning area, as requested by the Subcontractor, to assure uniformity of water content prior to placement. One water content shall be required for every 100 square yards after compaction in the placement area. In the placement area, uniformity of compaction is also confirmed with in-place nuclear densities with a minimum of one per 500 cubic yards or at least one per lift. To confirm by direct method the reliability of the nuclear densities, one in-place sand cone density is required for every 5000 cubic yards placed. These tests should be performed adjacent to the in-place nuclear density tests. To determine if the representative optimum water content is valid, one moisture-density relation is required for each 5000 cubic yards of clay placed (in conjunction with the sand cone density test).

Attached and part of revised Appendix V was Table 3, which presents the revised testing requirements.

Conclusions

Under the revised specification and employing the methods previously described, one crew would average 1000 tons of kaolin cap conditioned and compacted per ten (10) hour shift. May was the best production month with the crews averaging 1200 tons per ten (10) hour shift. In the heat of the South Carolina August, average crew production was only 960 tons per ten (10) hour shift. As previously stated, evaporation loss during the day shift was four (4) time as severe compared to moisture lost at night. Correspondingly, night shift production was about ten (10) percent greater than that achieved by the day shift. In total, some 541,000 tons of kaolin clay went into the closure cap.

Based on the experience and data from placing thos 541,000 tons of kaolin cap over this 58 acre site, it is concluded that:

1. Using standard heavy/highway construction equipment, raw clay can be:

Table 3. FIELD AND LABORATORY QUALITY CONTROL TESTING REQUIREMENTS FOR CLAY MATERIAL, FROM APPENDIX V - REV. 13, CONTRACT SPECIFICATIONS, MIXED WASTE MANAGEMENT FACILITY, DOE, SAVANNAH RIVER PLANT

	LAB IDENTIFICATION TEST SERIES INCLUDING:			FIELD QUALITY CONTROL TESTS				
LOCATION (1)	WATER CONTENT ASTM D2216-80 (2)	ATTERBERG LIMITS ASTM D4318-84 (3)	MINUS #200 SIEVE ASTM D1140-54 (4)	MOISTURE DENSITY RELATION ASTM D698-78 (5)	ONE POINT PROCTOR (6)	IN-PLACE NUCLEAR DENSITY ASTM D2922-81 (7)	WATER CONTENT ASTM D2216-80 (8)	IN-PLACE SAND CORE DENSITY (9)
BORROW PIT BEFORE MINING	ONE TEST SERIES FOR EACH MOISTURE-DENSITY RELATION			THREE FROM FACE BEING MINED				
DURING MINING	THREE TEST SERIES WHENEVER CHANGE IN MINING LOCATION							
STOCKPILE AREA	ONE TEST SERIES FOR EACH MOISTURE-DENSITY RELATION			THREE FROM INITIAL 500 TONS DELIVERED			ONE/100 TONS (IF STOCKPILE IS USED)	
CONDITIONING AREA							ONE/300 SQ YD (FOR INFORMATION ONLY)	
PLACEMENT AREA	ONE TEST SERIES FOR EACH MOISTURE-DENSITY RELATION			ONE/5000 CU YD ADJACENT TO IN-PLACE SAND CORE	ONE/EACH THIRD AND FIFTH LIFT OR AS DIRECTED BY FIELD ENGINEER	ONE/500 CU YD AT LEAST 1/LIFT	ONE/100 SQ YD	ONE/5000 CU YD ADJACENT TO IN-PLACE NUCLEAR DENSITY

a. Pulverized to minus 1-1/2 inch chunks.

b. Moisture conditioned.

c. Compacted by fully-penetrating feet which knead the clay for the full lift depth.

2. Uniform moisture application and conditioning requires special water truck distribution systems.

3. Specifications must fully take into account the natural variability of the selected capping or liner soil.

4. Moisture operations can be better controlled during night operations.

5. There are limits to soil testing precision which must be understood when developing project specifications.

6. Compaction procedures and acceptance criteria must be designed to produce moisture-density conditions that ensure levels of hydraulic conductivity. The appropriate acceptance criteria may be quite different from those required for stability of conventional earth embankments.

Acknowledgements

The authors wish to thank Miss Ann M. Schexayder, Nello L. Teer Company, for her efforts in assembling and sorting the raw field data from which this paper was developed. Mr. Jeff Newell of Chas. T. Main, Inc., was very helpful in providing a copy of his unpublished presentation, "Clay Cap Test Program for Mixed Waste Management Facility Closure at the Savannah River Site," which was given at the Vail, Colorado 1989, AEG meeting. Much of the information presented in the "Design Clay Cap Test Program," section originated with Mr. Newell. A special word of appreciation goes to Ms. Carine Fuller who typed this text and all of the correspondence during project construction.

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LESSONS LEARNED FROM REMEDIAL DESIGN OF THE HELEN KRAMER LANDFILL SUPERFUND SITE

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The Helen Kramer Landfill Superfund Site, in Gloucester County, New Jersey, is currently undergoing remedial action. The remedial design was developed by URS Consultants, Inc., under a Title I services contract to the U.S. Army Corps of Engineers, Kansas City District. The construction is being carried out by IT-Davy, a joint venture of International Technology Corporation (IT) and Davy McKee Corporation (Davy). As part of Title II services, URS is providing shop drawing review and engineering services during construction.

The site was ranked fourth on USEPA's National Priorities List. It includes a 66-acre refuse area and an 11-acre stressed area adjacent to a perennial stream, tributary to the Delaware River. The remedial action contract, in the amount of $55.7 million, represented the second largest single contract under the Superfund program at the time of award.

The remedial action includes an active gas collection and treatment system, a multilayer clay cap, a soil-bentonite slurry wall around the entire site, a leachate/groundwater collection system, and an onsite, 120-gpm pretreatment facility.

The design of the Helen Kramer Landfill Superfund Site remedial action is instructive at several levels. It comprises almost all those elements of remedial action that apply to containment and isolation of uncontrolled sites. It includes elements that are normally used to protect important potable water aquifers and surface water streams. The design process was enhanced by a comprehensive Value Engineering study, one of the first Superfund remedial designs to include such a feature. In all aspects, it was a very thorough effort on the part of all parties involved, and resulted in complete and clear construction bid documents. The process, however, was also instructive in unexpected areas, principally in the areas of access and real estate issues, interagency agreements, and the impact that these matters can have upon scheduling.

INTRODUCTION

On May 30, 1986, the U.S. Army Corps of Engineers (USACE), Kansas City District, awarded a contract (USACE Contract No. DACW41-86-C-0113) to URS Consultants, Inc. (formerly URS Company, Inc.), to design the Remedial Action at the Helen Kramer Superfund site. The design process comprised five discrete phases, with a delivery date scheduled for each phase. URS had also been authorized to conduct a Value Engineering study during design. The actual submittal dates for each phase (including the Value Engineering study), along with the originally scheduled dates, are shown in Table 1. The contract was advertised for bid by USACE on May 22, 1989, and awarded to the IT-Davy Joint Venture on October 6, 1989, with Notice to Proceed on November 13, 1989. At the time of this writing, construction is about 50 percent complete.

TABLE 1
SCHEDULED VS. ACTUAL MILESTONE DATES
HELEN KRAMER LANDFILL REMEDIAL DESIGN

	SCHEDULED			ACTUAL		
	START	SUBMITTAL	APPROVAL	START	SUBMITTAL	APPROVAL
PHASE I	6-16-86	7-16-86	8-5-86	6-16-86	7-16-86	8-26-86
PHASE II	8-5-86	10-19-86	11-8-86	10-24-86	1-9-87	3-16-87
PHASE III	11-8-86	1-7-87	1-27-87	3-16-87	-	-
VALUE ENG.	-	-	-	6-23-87	9-8-87	10-28-87
PHASE III	-	-	-	-	3-14-88	5-16-88
PHASE IV	1-27-87	3-28-87	4-17-87	4-27-88	6-25-88	9-16-88
PHASE V	4-17-87	5-2-87	5-2-87	9-1-88	9-16-88	9-16-88

BACKGROUND

Project Description

Site Location

The Helen Kramer Landfill site is located about five miles south of Woodbury, New Jersey. Edwards Run, a freshwater perennial stream, is located immediately east of and adjacent to the landfill. The site lies within the Delaware River drainage basin. Edwards Run empties into the Delaware River via Mantua Creek. A Site Plan showing remedial action components is presented in Figure 1.

Several residences are located near the landfill. The nearest housing development lies within 0.25 miles of the site. More than 3,000 persons live within one mile of the site and more than 6,000 within two miles. Natural resources near the site include agricultural lands, groundwater, and surface waters. The climate is characterized as temperate humid, with about 41 inches of average annual precipitation.

Site Description

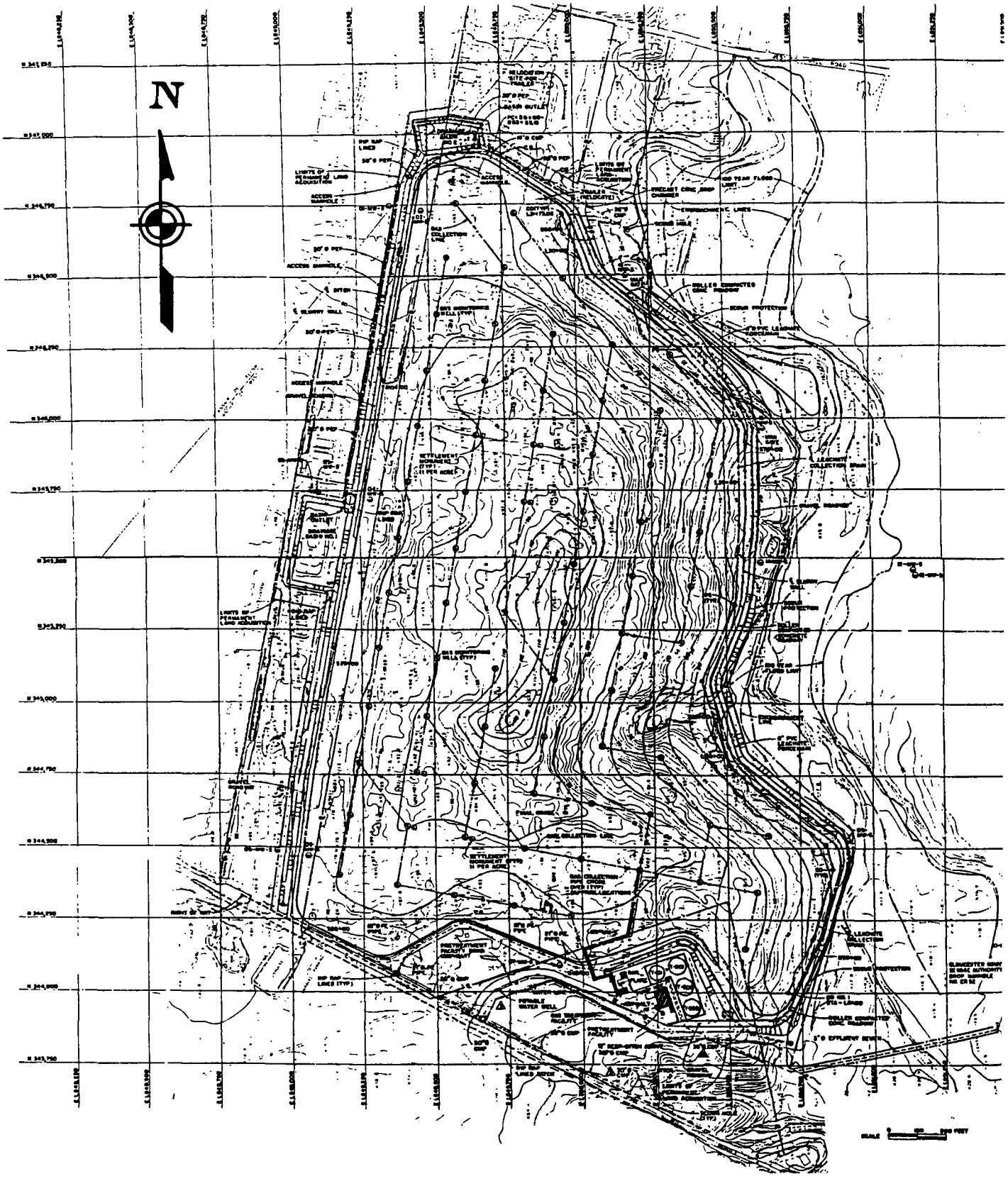
The 66-acre landfill contained approximately 2 million cubic yards of mounded waste, with waste thickness approaching more than 50 feet, and rising to as high as 50 feet above the surrounding terrain. The surface of the mound was generally undulating and irregular, with slopes approaching 50 percent. Relief from the creek bed to the top of the landfill was nearly 100 feet. An additional 11 acres between the landfill and Edwards Run had been stressed by landfill activities. A two- to three-acre pond, containing up to 2 million gallons of contaminated water, existed in the northeast corner of the site, in the flood plain of Edwards Run. Leachate from the landfill collected in this pond, with overflow going into Edwards Run. Numerous leachate seeps could be seen along the landfill slopes near the creek. A three-acre swamp located east-southeast of the landfill also collected leachate leaving the site. Vegetation in this swamp was stressed. A swampy area southeast of the landfill exhibited no stress. Landfill surface cover was extremely poor, and rifts in the surface, as well as protruding sharp objects, posed physical dangers. The site had no controlled drainage for surface runoff.

Site History

The site was used originally as a sand and gravel pit. It became an operating landfill between 1963 and 1965, during which time landfilling was carried on simultaneously with sand excavation. Little is known about landfilling activities prior to 1970.

In October 1973, inspectors from the New Jersey Department of Environmental Protection (NJDEP) noted that chemical wastes were being deposited in trenches on site. Further discoveries of chemical waste and drum disposal were made in January 1974 and, the following April, landfill leachate was observed discharging into Edwards Run. Dumping of chemical wastes, both in bulk and drums, was alleged by area residents to have continued into early 1981, when the landfill was closed by Court Order.

Between 1974 and 1983, limited-scope investigations were carried out by NJDEP and USEPA. These investigations showed that groundwater used by residents in the vicinity of the site had not been degraded, but that extensive contamination from the site was entering surface water, and that leachate was having toxic and possibly mutagenic effects on aquatic life. During 1981 a number of subsurface fires broke out at the landfill. Air monitoring conducted during these fires showed emissions of organic vapors and hydrogen cyanide. Consequently, in December 1982, USEPA prepared a Remedial



HELEN KRAMER SUPERFUND SITE

FIGURE 1

Action Master Plan for the site, and in 1983 conducted additional air monitoring, which confirmed the presence of organic vapors higher than background levels.

It is estimated that, of 2 million cubic yards of waste at this landfill, approximately 500,000 gallons was industrial liquid waste, several hundred cubic yards sludge, and over 3,000 cubic yards inorganic wastes (such as heavy metals, salts, catalysts, and the like). An estimated 183,000 gpd of leachate and contaminated groundwater was entering Edwards Run, threatening the quality of its water. [Edwards Run has potential as a recreational or irrigational resource.] Laboratory testing had indicated the potential for adverse effects upon biotic resources in Edwards Run. The shallow Mt. Laurel/Wenonah aquifer in the vicinity of the site and of Edwards Run was contaminated. Constantly generated landfill gas posed a danger of further fires as well as the possibility of further release of hazardous chemicals into the air. Although no potable water supplies had shown evidence of contamination attributable to the landfill, the potential for such contamination did exist due to their proximity to the site. Potential for present and long-term risk to human health and the environment provided justification for this site's being listed among the highest-priority sites on USEPA's National Priorities List.

The Remedial Investigations (RI) and Feasibility Study were conducted by NUS Corporation under USEPA Contract No. 68-01-6699, USEPA Work Assignment No. 29-2L30. Actual field work was conducted by NUS's subcontractor, R.E. Wright Associates, Inc., of Middletown, Pennsylvania, from August 1984 through September 1986.

Design Process

Phase I - Work Plan Development

USACE had developed a detailed Scope of Work for the project that was based upon RI/FS documents and that was consistent with the Record of Decision. Using this Scope, a fixed-price contract was awarded to URS Consultants, Inc. During the negotiations, a predetermined scope of subsurface investigations and completion schedule was agreed upon.

As part of Phase I, URS collected and reviewed the available technical information and developed a Work Plan document which, among other things, attempted to fill data gaps. During the review of these documents, however, technical experts on the joint (USACE/USEPA/NJDEP/URS) project team concluded that the planned investigations were not adequate and that a much more extensive investigation program was necessary in order to prepare bid documents for competitive bidding. Since monies for these investigations had not been included in the original contract amount, this issue required further discussion and contract modification. This delayed the initiation of Phase II by more than two months.

Phase II - Predesign Investigation (35% Design)

This phase required an $800,000 level of effort within a period of 75 calendar days, including collection, synthesis, and interpretation of data and preparation of a report, along with 35% design. The job was challenging, considering the potential for mishaps when drilling in an uncontrolled landfill. A great deal of credit was due to the joint project team and to URS's subcontractors for completion of the work by the newly approved completion date.

Interval Between Phase II and Phase III

One of the requirements of Phase II was to present to USACE a recommendation for Value Engineering Studies. The following five items were identified for Value Engineering:

- A study of groundwater flow conditions, including effects of remedial action upon groundwater levels, the need for a subsurface drain upgradient of the slurry wall, and the economic benefits of such a drain.

- A study of the benefits and costs of constructing a slurry wall along Edwards Run.

- A study of the impact of variations in aquifer permeability on project design.

- A study of the viability and benefits of downsizing the pretreatment plant.

- A study of the costs of pretreatment and discharge to a POTW vs. complete treatment and discharge to surface water of groundwater/leachate on site.

USACE issued a modification to URS's contract authorizing URS to conduct studies on the first 4 items only. Despite the complexity of the 3-D Model of this site, the VE Study was completed and submitted in 78 days from Notice to Proceed. The following 8 findings were accepted for inclusion in the design:

1) Implementation of remedial action at the site would cause an upward groundwater flow beneath the entire site, preventing the possibility of contaminant migration downward or laterally.

2) The rise of groundwater levels upgradient of the slurry wall should be inconsequential enough as to require no mitigative measures.

3) A subsurface drain upgradient of the slurry wall would not appreciably reduce flows to the collection drain. Such a drain is therefore not considered necessary.

4) The Marshalltown formation (underlying the Mt. Laurel/Wenonah aquifer), although not clayey, acts as an aquitard and provides an adequate foundation for slurry wall key.

5) The variations in Marshalltown permeability have a direct and profound impact upon flows to the leachate collection drain.

6) Due to the fact that lateral flow is insignificant within the Marshalltown, the depth of slurry wall key is not of great importance. A 5-foot key is adequate.

7) A smaller pretreatment plant is viable and would be economical. Economy would be greater if the facility were sized for flows that assume a slurry wall between the collection drain and Edwards Run.

8) The construction of such a slurry wall is technically feasible, and such a slurry wall would provide a higher degree of reliability in the planned remedial action.

The required modification to the contract impacted the schedule of the next phase. It also included a slurry wall on the east side of the project. Moreover, it became apparent that it would be preferable if the design could be developed with no floodway encroachment. [Encroachment would have been extensive if the original (FS Stage) concept were implemented.] Additional investigation seemed to be warranted, but two things worked against this: (1) the need to complete the bid documents expeditiously (the original completion date having long since passed), and (2) the difficulty of gaining legal and physical access to the site. It was therefore concluded that the design would be

developed using existing information, extrapolating to the areas where investigations could not be conducted. This would become an important issue during the construction phase of the project.

Another factor entering the picture was the pretreatment criteria (for leachate/groundwater) set by the Publicly Owned Treatment Works (POTW), which in this case was the Gloucester County Utilities Authority (GCUA). GCUA and USEPA negotiators ultimately agreed to a batch-discharge to GCUA's system. This of course meant that no discharge to GCUA sewers would be permitted without prior testing/approval. This decision required adding a minimum of three pretreated wastewater discharge/holding tanks to the project, each with a capacity of 350,000 gallons. After receiving verbal approvals from the GCUA board, a draft Service Agreement developed by USEPA was sent to GCUA for review and comment.

Phase III - 65% Design

With all previously identified elements included in the project scope, this phase was targeted for completion within 60 calendar days. This phase proceeded smoothly.

Phase IV - 95% Design

This phase was carried out without serious difficulty and on schedule. However, it is worthy of mention here that in spite of the design being almost ready for bid invitation, little progress had been made on two important issues. These issues included, on the one hand, real estate access and easements for construction, and, on the other, an agreement with the POTW to accept pretreated leachate. These issues had not yet been settled. Both issues were vital if any remedial construction were to begin.

During this phase two major engineering issues had to be overcome: completion of the landfill cap in such a way that remedial action would not encroach upon the floodway of Edwards Run; and construction of a slurry wall across the steep banks on the northeast and southeast ends of the landfill. After several alternatives had been studied, Roller-Compacted Concrete (RCC) was incorporated into the design. This feature promised not only to provide support to the cap, but also made it possible to construct the slurry wall by creating somewhat milder slopes.

Phase V - 100% Design

Following review of the Phase IV submittal, specifications and drawings were finalized and submitted to USACE on September 16, 1988, in anticipation of bid invitation to follow shortly.

Invitation to Bid

The formal invitation to bid was not advertised until May 22, 1989, with bid opening on September 19, 1989, one year following completion of the design. As stated earlier, real estate adjoining the landfill site, acquisition of which was required for construction of the remedial action, had not yet been acquired. USACE was of the opinion that until all the real estate issues were resolved, the United States Government could not enter into a legal contract for construction.

Although more than 200 bid packages had been sold by USACE--the cost of bid packages being set low ($10.00) to encourage more bids--only three responsive bids were received. All bids were substantially higher than the original Government estimate. A large number of potential bidders were unable to secure bonds in the amount necessary to undertake the project. They claimed that even though their firms were technically and financially qualified to complete the work, the bonding

requirements denied them the opportunity to submit a bid that, as they maintained, would have been advantageous to the Government.

Real Estate and Site Access

Access was needed to adjacent properties owned by parties other than the landfill owner. Two of the three property owners in question owned land uncontaminated by the landfill. Six different access procedures were used to acquire this land. These included purchase, leasing, relocation, condemnation, access agreement, and an administrative order. Extensive negotiations were required, making the process last an unexpectedly long time. The benefits of expediting the development of the bid documents were essentially lost, and it resulted that real-estate issues had the greatest impact on the remediation schedule.

This was one of the first acquisitions of property for the purposes of conducting a remedial action that had been made through the Superfund program.

Remedial Action Construction

The Contractor began site work on February 20, 1990, and to date has completed 50 percent of the remedial construction. From an engineering design point of view, two construction issues are worthy of consideration: pretreatment plant design modifications, and construction of the RCC and the slurry wall along Edwards Run.

Pretreatment Plant Design Modifications

This component of the remedial action, which is on a critical path, was originally scheduled for completion for November 3, 1990. The facility would have then been available for treatment of leachate and any contaminated groundwater from construction activities. In April 1990, however, the project team was informed that GCUA pretreatment requirements (discharge criteria) had been changed from those used in the plant design, and made more stringent. In order to meet these requirements, a new engineering study had to be completed, and design modifications made. The two key elements of the required process enhancements (water-phase activated carbon adsorbers and a high-efficiency air stripper) were long-lead items. This fact, along with the necessary supporting design drawing modifications and the contract modification process, caused the target date for pretreatment plant completion to be pushed back to August 1991. This has had an impact on both the cost and the overall project completion date.

Construction of RCC and Slurry Wall Along Edwards Run

The contract documents required the Contractor to drill a certain number of soil borings to define the depth to the geological formation (Marshalltown) into which the slurry wall was to be keyed. Based upon these investigations, the Contractor claimed that the ground was softer than he had anticipated and further stated his opinion that the ground was possibly even unsuitable for support of the RCC. This portion of the site had been the least explored. The meandering of the stream (Edwards Run) had extensively reworked the soils. Additionally, sand and gravel mining, followed by landfilling activities had further complicated the situation. To obtain more accurate data, the Contractor was directed to undertake a detailed investigation of this area under USACE direction. The results of this investigation revealed that the geologic soil formation expected over most of this portion of the site had been removed by stream erosion processes and had been replaced by a heterogeneous matrix of floodplain alluvium of inconsistent texture and density. The depth to firm ground was variable at best, and deeper than expected. Increased excavation depths also brought into focus potentially larger volumes of contaminated groundwater. The stability of the excavation for the foundation became

important, requiring greater care in planning and execution. The net result again was an increase in cost and an impact on schedule. As of this writing, it is still a matter of study whether conventional construction methods or in-situ ground stabilization would be more suitable.

CONCLUSIONS

What may be deduced from this experience, for application on Superfund remedial projects of similar scope, nature, and complexity? The most important lessons are the following:

1. The scope and costs of predesign investigations can be substantial, and greatly variable, depending upon the degree of detail to which the investigations were carried during the RI/FS process. It is prudent to define a scope acceptable to all parties before negotiating a fixed-price design contract. We have already seen this change take place on design contracts being negotiated in the recent past.

2. Field investigations must be completed during the design process. Such investigations, when left to the construction phase, can have a major impact on construction cost and schedule. This point cannot be overstressed.

3. Real estate issues must be defined early in the design and should be given the same priority as other elements of the project, if not a higher priority. Many times these issues involve high-priced real estate, farmland, or property with sentimental value for its owners. Property acquisition should be complete, or nearly so, prior to 100% design.

4. When interagency agreements are involved, these agreements must be executed prior to completion of bid documents. Incorporation of new technical or contractual requirements during construction is costly and delays construction.

5. Agency review has an important impact on project team continuity and cost.

6. The importance of early and continuing attention to POTW issues cannot be overstated.

The Helen Kramer Landfill Superfund site remedial design has, at many levels, been instructive. In spite of the difficulties encountered, however, this remedial design is considered to have been a success that has set precedents in many areas.

DISCLAIMER

This paper has undergone a relatively broad initial, but not formal, peer review. Therefore it does not necessarily reflect the views or policies of URS, USEPA, or USACE. It does not constitute any rulemaking, policy, or guidance by USEPA or USACE, and cannot be relied upon to create a substantive or procedural right enforceable by any party. Neither URS nor the United States Government nor any of its employees, contractors, subcontractors, or their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for any third party's use or the results of such use of any information or procedure disclosed in this report, or represents that its use by such third party would not infringe on privately owned rights.

We encourage your comments on the utility of this paper and how it might be improved to better serve the Superfund program's needs. Comments may be forwarded to the attention of:

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Contract Security in Superfund: An Open Dialogue Between Government and the Remedial Construction Industry

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INTRODUCTION

In the late 1980's as the larger and more complex EPA Superfund projects developed under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Superfund Amendments and Reauthorization Act (SARA), serious liability concerns began to confront the construction industry. The liability exposure that remedial action contractors began to face on hazardous waste projects had a profound effect upon the construction surety bond market and changed approaches to contract performance security in a major way. Many of the early hazardous waste problems, particularly in the government realm, were handled as conventional public works jobs involving standard civil engineering and construction practices. As such, these projects were structured with design plans and construction specifications serving as contract documents accompanied by the customary performance bonds and payment bonds.

With the advancement of the larger hazardous waste projects through the investigation and design stages into the construction phase, federal and state governments as well as private industrial owners have begun to experience difficulty in obtaining bonding for their projects. Owners and especially surety companies are forced to deal with the complex liability issues that abound in CERCLA, SARA and hazardous waste in general. In view of the long-term liability concerns that face the surety industry, a conservative approach to bonding hazardous waste work quickly evolved. The resulting impact on remedial action construction projects has been of special concern in the government sector. Lack of bonding has caused project delays from inability to solicit bids or created exceedingly high costs from lack of a competitive arena. Consequently, government entities have been forced to modify conventional approaches to construction contracts and to seek innovative solutions to performance security needs -all within existing state and federal law. Closer examination of both contracting options and financial risk exposure has provided new insight into the contractual solutions of hazardous waste problems.

BACKGROUND

In the summer of 1988, the Texas Water Commission completed the Remedial Design of the Sikes Disposal Pits Superfund Site and received EPA approval of the plans and specifications. The Sikes Site, located in Harris County near the Town of Crosby and northeast of Houston, is an abandoned hazardous waste dump area along the San Jacinto River bottom. Large sand pits and smaller depressions scattered over 100 acres of this floodway became receptacles for the disposal of mixed industrial wastes and refuse during most of the 1960's.

The Record of Decision called for the excavation of contaminated materials with thermal destruction on site. Involving the handling of over a half million yards of material and the incineration of over 210,000 tons of wastes, the Sikes project was the largest single Superfund remedy to be offered for bids in the nation. The remedial design embraces a performance-based approach toward contracting for the incineration services and for treatment of large volumes of contaminated shallow ground water appurtenant to the excavation operations. Following completion of incineration, all temporary remediation facilities are to be removed from the site and followed by fine grading and revegetation of the landscape.

In August, 1988, the Request for Proposals for remediation of the Sikes site was advertised nationwide in a two-step procurement approach to the contract for incineration services. Five remedial action contractors were deemed qualified to submit bids for the project. The contract for which bids were solicited contained the standard "public works" contract security requirements of a bid bond of the customary 5% and the payment bond of the standard 100%. The performance bond was specified to be $35,000,000 on this contract having an estimated total cost of $91,600,00.

Bids for the Sikes Remedial Action were opened on October 12, 1989 but the contract was not awarded. Of the five contractors invited to bid, only two bids were received. One bid was determined to be non-responsive, as it was not accompanied by the required bid bond. The other bid was almost 50% more than the design engineer's cost estimate and exceeded the funds obligated by the TWC and EPA for this project.

THE DIALOGUE

In seeking reasons for the lack of competitive bids, EPA and the Texas Water Commission interviewed the other three contractors who had not submitted bids. All three companies cited either bonding difficulties or liability concerns as reasons for declining to bid. Other interviews and contacts with surety company representatives were initiated and significant information-gathering activity was exerted by both state and EPA.

In discussions with contractors, bonding companies and other government representatives, several messages became apparent regarding the contracting climate in hazardous waste. There is general concern among the sureties that the performance guarantee bond will at some time in the future be construed by a court of law, in the absence of other relief, as a kind of insurance policy to compensate individuals for perceived harm suffered from the waste cleanup project. Apparently, there is also concern that some hazardous waste projects may present the potential for a release of environmental pollutants so catastrophic as to bankrupt the contractor into literal non-performance hardship. The repeated point of concern was the potential for the designation under hazardous waste laws of strict liability to the contractor on third-party claims. Strict liability, being liability without a determination of pure fault, may hold a contractor liable, even though negligence is not shown. The joint and several liability provisions of CERLA and SARA intensify the possibility of total liability, even if a contractor were responsible for only slight contamination.

Other contractors and surety representatives cited:

- Design/build concept on projects where the contractor may be held accountable for the method or scope of the remedy;
- Uncertain hazards associated with unknown materials at the site;
- Unnecessarily stringent cleanup criteria;

- Lack of pollution liability insurance and uncertainty regarding the extension of SARA Section 119 indemnification to bonding companies taking over projects;

- Concern that there is a limited amount of money in the EPA Trust Fund and the possibility of the fund being nonexistent in the future;

- Inability of sureties to choose a completion option in a default and the possibility of additional liability associated with the surety's being a facilitator of waste disposal.

Of universal concern to the bonding companies seems to be the project type/ project size ratio, especially in hazardous waste. That is, a surety is frequently willing to bond a small Superfund contract and is accustomed to bonding very large but traditional civil construction projects. However, due to the liability concerns expressed above, the bonding company is apparently reticent about underwriting a large hazardous waste project such as Sikes.

Of particular concern to the contractors interviewed were several common issues and questions:

- Insistence by government in requiring surety bonds but not accepting other contract security instruments such as letters of credit;

- Amount of contract security and the need for any performance guarantee on a service-type contract;

- Possibility of separating a remediation project such as Sikes into segments resulting in some clean, less-risky conventional contracts and some hazardous waste handling contracts;

- Advantages of limiting retainage from progress payments to some reasonable maximum, particularly on a large service-type contract;

- Expressed written intent of the purpose of the surety bond as a guarantee of contract performance and not as an instrument of relief for third-party damage claims;

- Established time limit on the protection extended by the bond and a formal execution of a release of the bond upon completion of the work.

- Elimination of any warranty or post-completion guarantees from the contract provisions whereby the success of the remedy cannot be guaranteed by the contractor in any case.

SOLUTIONS AND RESOLUTIONS

This dialogue with the remedial contractors helped build the framework for establishing several contract modifications, which would hopefully result in a contract procurement package more palatable to the construction market. Careful study of existing bonding and contract law affecting federal and state government procurement preceded the formulation of stated policies and revised procedure for the needed modifications.

The extent of bonding requirements under both state and federal law was closely examined since the project is 90% federally funded but is administrated by the State of Texas. The proposed Water Commission contract for site remediation, while partially funded by EPA, would not be a federal contract since the federal government is not a signatory of the contract. It was further noted that the

federal law permits flexibility in evaluating the required amount of bonding. What had been cause for some consternation with the surety companies interviewed was the Texas McGregor Act, which requires 100% performance and payment bonds for the construction of public works in excess of $25,000. The legal staff of the Water Commission issued a determination in early 1990 that the Sikes Remedial Action Contract was for waste incineration services to be performed wholly on private property and further that the project did not involve the erection of permanent structures or public facilities and was therefore not within the concept of public works. While other Superfund projects may incorporate the construction of permanent structures such as landfills, even if on private property, the Sikes remediation encompasses neither public nor permanent facilities.

EPA and the Texas Water Commission decided that the government's interest in the project certainly needed some measure of protection against failed performance, project abandonment and unpaid subcontract material and labor claims. After studying the history and procedures involved in bank letters of credit, the Commission made the commitment to accept these instruments for contract security under certain specific conditions. Since the staff felt it would be exceedingly difficult to dispense numerous payments on unpaid claims to vendors, subcontractors and laborers, in the event of contractor default, it was agreed that some amount of payment bond should be required.

To reduce the sureties' concerns with very costly Superfund projects, the TWC and EPA decided to divide the project into two clearly separate phases with separate contracts. The Phase A contract was structured as essentially clean work involving site preparation with mobilization and erection of incineration and water treatment equipment. Excavation and handling of hazardous waste was left to the second or Phase B contract for destruction of contaminants. Modifications to the bid proposal moved hazardous work from Phase A to Phase B. Completion of Phase A would be established upon installation and mechanical demonstration of all project facilities. The trial burn of the incinerator, where operating parameters are defined and acceptable results are proven with the actual hazardous materials from the site, was then to be the first item of work in the second contract, Phase B.

With the segregation of work into two separate contracts, the work would be supported by separate contract security instruments as well. A letter of credit to guarantee performance or a conventional performance bond plus the desired payment bond would accompany each contract, one independent of the other. Due to the phased funding of the Sikes project from EPA, both contracts would not be executed at the outset. Rather, the contract security instruments for the Phase A contract would be formally released upon completion of that phase simultaneously with submittal of papers of guarantee for Phase B along with the Commission's release of the Phase B contract and Notice to Proceed to the contractor. All of this served to break a very large contract into smaller and hopefully more bondable contracts with the terms of possible liability for each more limited.

In response to the input of concerns from surety company representatives, the Water Commission staff modified the conventional bond forms and established new policy regarding several issues:

- The Performance Bond would contain wording that makes it clear that the sole guarantee was for completion of the required remediation and not to be construed as any form of insurance against future third-party damage claims;

- Letters of credit and/or bonds would be formally released and returned to the contractor upon successful completion of each contract, thus limiting the term of liability under each guarantee;

- Surety companies were permitted some options with regard to the project completion fulfillment in the event of contractor default;

- Memoranda from EPA were distributed to bidders indicating that SARA 119 indemnification of the contractor would be extended to the surety company in its role as a completing agent in the event of default.

The Water Commission and EPA staff conducted a thorough risk review of the project. After analyzing job cost estimates, type of work involved in separated phases, and possible cost impacts associated with default or abandonment, we established a performance security amount of $20 million for each contract. As stated before, a payment bond was needed to assure payment of vendors, subcontractors and laborers, and the payment bond amount was set at $5 million. Terms for strict proof of payment and provisions for seizure of facilities under default were added to contract. The required performance and payment security amounts were set at the same $20 and $5 million for both Phase A and Phase B contracts. As discussed previously, these security instruments would be submitted and executed separately for the two contracts in a hand-off fashion so that bonds and letters for both would not be in effect at the same time.

Bidders had all pointed out the impact of the full 10% retainage on a project the magnitude of Sikes and requested some established ceiling on the retained payment amounts. The potential cost savings to the government were deemed quite significant. The Commission, with EPA approval, capped the retainage during the costlier Phase B work at $2 million. This will be held until project completion with the possibility of further reduction toward the end of the project.

RESULTS AND CONCLUSION

After making these changes to the contract documents, the Texas Water Commission reissued the Invitation for Bids at the end of 1989. Project bids were opened for the second time on March 8, 1990, with much success. Of the five qualified proposers, four contractors submitted bids in a very competitive range. The low bid was just under $90,000,000, two bids were for just over $95,000,000 and the highest bid was just over $98,000,000. The government's estimate for this modified construction contract was slightly under $95,000,000. Because the spread between the high bid and the low bid was only 10%, we are satisfied that all contractors were on equal footing. The Phase A and Phase B contracts, subsequently awarded to the low bidder without protest, are each secured by a $20 million letter of credit and the required $5 million payment bond.

Phase A work at Sikes is underway and on schedule. The open dialogue between government and the remedial action contracting industry was responsible for substantial savings to the state and federal governments and for the success of procurement under difficult circumstances with the development and execution of innovative contracting procedures.

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Remedial Design and Construction at the Charles George Landfill Superfund Site

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INTRODUCTION

Capping as a form of source control is a common remedy for many hazardous and non-hazardous waste sites. Traditional issues associated with cap design include, among others, cost-effectiveness, permeability criteria, redundancy, cap material, constructibility and quality control, subsidence and long term stability, gas and leachate collection and ease of operation and maintenance (O&M). Capping materials range from natural soils to synthetic membranes, and cap designs have differed from site to site. The long term effectiveness at minimizing the release of contaminants is a function of both cap design and construction quality, O&M, local groundwater conditions and pre-capping operational history.

This paper addresses the recent Superfund-financed construction of a 53 acre (as the footprint) synthetic landfill cap, with emphasis on the technical and programmatic lessons learned. This cap construction will be discussed within the context of the parameters listed above, as well as within the three other operable units being implemented at this site. These other remedies at the Charles George site include the provision of municipal water supply and the treatment of landfill gas, contaminated groundwater and leachate. As more Superfund sites advance beyond the characterization, planning and design stages, we believe that the implementation issues encountered at this "older" site, together with our resolutions, should be shared to provide for smoother site clean ups and less-problematic cost recovery cases elsewhere.

BACKGROUND

Located in a predominantly rural residential area 30 miles northwest of Boston in Tyngsboro, Massachusetts, this site began as a small (< 1 acre) local dump in the mid-1950s. The George family purchased the site in 1967 and significantly expanded landfill operations until shut down per order of the state Attorney General in 1983. The landfill operated as a state-licensed hazardous waste disposal site from 1973 to 1976, and, as listed in monthly operation reports, 5,509 drums and more than 1,040 yd^3 of metal sludges ("Toxic Metal etc.") were disposed at the site during this time frame. (Depending on the interpretation of the monthly reports filed during these years, however, one could

easily argue that the 1,040 yd^3 amount should be approximately 4,280 yd^3). Other bulk liquid and industrial/chemical wastes were probably disposed during other times as well. In total, approximately 4 million yd^3 of mixed wastes have been disposed at the site.

A plan view of the landfill and surrounding area prior to cap construction is presented in Figure 1. The landfill had typical relief of about 50 ft with a maximum of about 90 ft at the western end. Landfill slopes varied from about 1V on 5H in the northwestern corner, where the landfill access road and operations buildings were located, to a very steep 1V on 2H at the western end. At least in some areas, waste was placed at water table or bedrock depths as much as 20 ft below natural grade. In other areas waste was disposed directly on native soils ranging from silty glacial till to sand and gravel.

Two limited leachate collection and recirculation systems were installed by the owners during 1980 and 1981, but were plagued with operational problems. As a result, the eastern leachate system drained into a combined surface runoff/leachate lagoon at the eastern perimeter of the fill. A similar lagoon perched on the steep slope of the western perimeter received leachate from the western leachate system. Prior to closure, contaminated storm runoff frequently ponded a local road, and, in the summer of 1980, a landfill fire burned at the site for approximately two months. Beginning in 1980, volatile organic compounds (VOCs) detected in site groundwater (e.g., acetone, 2-butanone, benzene, etc.) were detected in the two deep bedrock water supply wells of a nearby condominium complex. Pumpage of these 500 foot deep supply wells, located 800 feet south of the eastern lobe of the landfill, influenced the site's eastern groundwater plume and pulled groundwater contaminants downward and southward (Reference 1). These wells were ordered closed by the state in 1982.

The site was added to the Superfund National Priorities List in 1983. From August 1983 through March 1984, emergency response actions were implemented involving a) the upgrade of an emergency overland waterline serving the condominium complex, b) the coverage of approximately 20 acres of exposed refuse and c) the installation of 12 shallow gas vents. In December 1983, EPA issued the first of three Records of Decision (RODs) for the site which called for an extension of an existing municipal water supply to serve the condominium area. Construction of this waterline, a 5 mile extension to the City of Lowell's system, began in September 1986 and was completed in October 1988. The second ROD, issued in July 1985, selected a high density polyethylene (HDPE) cap for the entire landfill, together with perimeter leachate collection and gas venting. Mobilization for the cap construction began in December 1988, and the cap was completed in October 1990. The leachate collection system was activated in January 1991, although start up problems have been experienced. The third ROD, issued in September 1988, addressed leachate, contaminated groundwater, landfill gas and sediments. These "phase three" remedies are currently in design.

As part of the extensive cost recovery litigation related to this site, all of EPA's remedies have been aggressively criticized. Regarding the second (cap) ROD, defendants argue, among other things, that the 10^{-7} cm/sec permeability design criteria was inappropriate, and that a glacial till cap would have been more cost-effective and permanent than an HDPE one, especially given the high (3.5 ft/yr maximum) subsidence rates observed. These arguments have been extensively reviewed by the Agency, and, as discussed further below, EPA maintains that its remedy selections have been appropriate. For a more comprehensive reading of the litigation remedial issues, see References 2, 3, 4 and 5.

DISCUSSION

A. Cap Design

EPA Region I contracted with Camp, Dresser and McKee Inc. (CDM) to develop the cap design. Review of the design was conducted by EPA, the Omaha District and New England Division of the Army Corps of Engineers (the Corps), the Massachusetts Department of Environmental Protection (DEP), and, to a limited extent, a local Citizens Advisory Committee (CAC).

The design uses a 60 mil (1.5 mm) textured HDPE geomembrane as the only critical impermeable layer of the synthetic cap composite (Figure 2). HDPE was selected because of its superior performance and availability compared to the other alternatives considered during feasibility studies. Note that the design includes a woven geofabric as the upper-most layer for additional strength. The design also uses synthetic geonets above and below the HDPE membrane as the drainage layers for excessive soil moisture runoff and leachate/gas transport, respectively. On the side slopes, the design called for 12 inches of crushed stone (and no upper geonet) rather than the 18 inches of vegetated soil used on the landfill crest.

Runoff is now drained to one of three sedimentation basins via a perimeter rip-rapped drainage swale, and leachate is collected by a new french toe-drain located just inside this drainage swale (Figure 3). A gabion-lined side slope bench was included in the design to assist in erosion control, woven fabric anchoring and access during O&M. The 12 original gas vents have been connected to the new expanded gas collection system via gravel trenches located below the cap. The 28 new vents that penetrate the HDPE membrane are interconnected by a similar trench system as well as by the lower geonet. The as-built plan of the cap is presented in Figure 4.

The maximum slope allowed per the design is 1V on 3H to aid in liner installation, slope stability and ease of O&M. This required that surrounding property be purchased, by the state, in order to extend and flatten the slopes.

The new perimeter leachate collection system consists of a perforated HDPE pipe within an HDPE-lined trench, and was designed primarily to collect side slope seepage draining from the lower geonet. The original eastern and western leachate collection systems are tied-in to the new system, however. In the original cap design, leachate was drained by gravity to two underground storage tank (UST) sites. Taking advantage of the site topography, one UST site was located on the eastern perimeter and the other on the western perimeter. Each site was designed to include two 7,000 gal USTs. No provisions were made in the construction contract for treatment of this leachate, since this was outside the scope of ROD II. The original design also called for three temporary percolation pits to be used for lagoon and general construction dewatering.

B. Subsidence

It is generally acknowledged that localized subsidence is more of a problem with older landfills where proper operations (e.g., placement, compaction, interim cover) were not followed. During the design of this cap, landfill settlement and localized subsidence were analyzed based on existing literature. The high strength woven geotextile (Figure 2) was included to protect against potential differential settlements greater than those expected based on the literature. However, due to fissures in the fill and evidence of settlement at the two landfill groundwater monitoring wells observed in late 1987, a more rigorous site-specific analysis was performed. Based on two areal mappings dated approximately 3 years apart (Reference 6), four optical cross-section surveys conducted between October 1988 and April 1989 (Reference 7), and biaxial stress testing of the woven geotextile and the HDPE geomembrane performed in October 1989 (Reference 8), it was concluded that the cap

composite as designed will be able to withstand settlement-related forces with proper maintenance (Reference 9, 10).

C. Cap Construction

The construction contract was advertized for bids in Spring 1988, after access rights for construction had been secured by federal court order. Six bids were received ranging from $13,800,000 to $23,300,000, and the contract was awarded to Tricil Environmental Services on July 22, 1988 at a cost of $15,567,675. On July 28, 1988 one of the unsuccessful bidders protested the award and delayed mobilization until December 1988. Note that actual construction costs specific to the impermeable HDPE layer, including material, transportation, installation and quality control came to $0.60/ft^2 ($0.31/ft^2 for material + $0.29/ft^2 for installation), for a total of $1,723,638 (Reference 11). This compares favorably to the defendants' cost estimate of $2,030,000 for installation of 2 ft of glacial till (Reference 2).

The contractor's first effort on site was to clear the area, demolish buildings and install the perimeter fence. Next, fill was placed on the site to produce the maximum 1V on 3H slope, and to provide a smooth subgrade for the HDPE membrane. As the slopes were flattened, the gas collection trenches and vents and the various cap components were installed. Several vents were relocated during construction to areas where landfill gases were naturally venting. Not surprisingly, as the liner was installed more and more gas was forced through the vents. Workers used blowers, respirators and, in some cases, supplied-oxygen when working in gaseous areas.

Construction meetings involving Tricil, the Corps, EPA and the DEP were held weekly to discuss the various construction issues and monitor the project's progress. Weekly construction tours were also provided to the defendants' consultant during most of the construction period.

Liner installation occurred over two summers. Even with the synthetic cap materials, rain delays were frequent. One day of rain could cause several days of delay due to the time required to sufficiently dry the subgrade soil. In addition, rain would wash soil from unlined areas on to the partially installed cap. This material in turn would have to be removed prior to further cap installation. Finally, any soil that was washed out had to be replaced and compacted. Later in construction a more granular fill was allowed as the subgrade material under the cap composite. This material did not wash out as did the previously used material, it dried more quickly, and allowed for a more efficient liner installation.

The percolation pits of the original design were not built for two reasons. First, buried refuse was discovered at one location and second, in-situ permeabilities appeared to be too low to allow for effective percolation. As a result, a lined holding pond was built just north of the landfill to contain the western lagoon and contaminated runoff from other areas. The eastern sedimentation basin was used to contain contaminated runoff in that area. Both basins were subsequently drained without treatment after toxicity testing demonstrated that the ponded water was acceptable for discharge.

Perhaps the biggest change to the design involved deleting the two leachate USTs, and replacing them with a pumping system designed to centralize all site leachate to the lined holding pond discussed above. This was done to avoid construction issues (e.g., blasting, contaminated groundwater) and the need for frequent tank draining, and to help integrate leachate collection with the phase three treatment remedies. This new system includes two pump stations, one on either end of the landfill, and a force main from each one which travels within the leachate toe-drain to the holding pond. This allows for increased, centralized storage, and should provide for a more efficient interim leachate management program until the on-site treatment plant is built per ROD III. Ironically, one of the more difficult and time consuming tasks for this system was coordinating with the electrical utility

company (among other problems, they refuse to set foot on Superfund sites). Unfortunately, start-up problems involving the submergible pumps and their start-up capacitors have hampered full usage of the collection system. A more specific response time requirement in the contract's warranty clause could have improved the contractors' pump repair response times. The pump repair problems have been compounded by safety concerns due to significant volumes of gas being collected by the leachate toe-drain.

Another significant change from the original design involved the side-slope bench gabions. The contractor questioned the necessity of the gabion's gutter function and the constructibility of the gabions, and proceeded with an interim crushed stone bench to satisfy the anchoring and access functions of the bench. A compromise was reached wherein if subsequent side slope erosion indicates the need for additional drainage control, the existing crushed stone bench will be modified accordingly.

The local community and CAC were also involved during construction. Their concerns included, among others, truck traffic, road damage, erosion, the percolation pits, and bedrock blasting. Initially, evening meetings were held every two weeks to discuss these issues, eventually tapering to approximately one per month. Their adamant opposition to bedrock blasting was one factor in the change from leachate USTs to pump stations, and also resulted in the contractor using mechanical rock removal rather than blasting.

Value engineering (VE) during construction was very time consuming. Both the contractor and the Corps' resident engineer actively engaged in submitting VE proposals. This is of course an accepted and encouraged practice. However, in this instance review and approval of each proposal required lengthy coordination and technical review among the Corps, EPA and the DEP. This often resulted in considerable delays in the review process since concurrence by all three parties was necessary. To compound the problem, rejected VE proposals were revised and submitted to readdress the original design issue, especially regarding the side slope bench and the cover soil design. Regardless of these issues, however, many VE proposals were successfully implemented. The formal VE study performed during the phase three design should help avoid similar problems during the next round of construction.

Finally, due to the subsidence concerns discussed above, as well as the on-going site litigation, a stop-work order was issued to temporarily prohibit placement of the soil materials above the cap. This allowed for a formal solicitation of comments regarding the type and depth of these materials, especially in regard to the loads applied on the synthetic composite. Ultimately, the order was lifted and the cover materials immediately above the cap were installed as originally designed (Figure 2).

D. Groundwater Monitoring During Cap Construction

Pursuant to an Administrative Order by Consent (AOC), a year long groundwater monitoring program was undertaken by certain Potentially Responsible Parties (PRP) from November 1989 to October 1990. Consistent with a requirement in the third ROD for 12 consecutive months of compliance monitoring, four wells (two couplets) in the eastern groundwater plume were monitored monthly during this time. Also as part of this study, nine other site wells were monitored quarterly, and water table elevations in 50 site wells were monitored monthly.

For most VOCs, the concentrations reported in this study for the eastern overburden plume were significantly greater than as measured in early 1987 and March 1989, and several fluctuated markedly throughout the 12 month monitoring period (Table 1) (Reference 12). In the most contaminated well in this area (E&E/FIT 2), benzene concentrations ranged from 0.5 - 5.2 mg/L, and arsenic concentrations ranged from 0.07 - 0.26 mg/L. Note that tetrahydrofuran, a VOC not included in

EPA's Contract Lab Program target compound list, appears to be the most prevalent and most highly concentrated VOC at the site, reported at a maximum of 11 mg/L (this compound was analytically identified by EPA's National Enforcement Investigations Center in Denver, CO). Hypotheses for these increased contaminant loadings include a) barrel deterioration and thus new sources within the fill, b) reduced dilution as a result of capping, c) increased loadings as a function of construction activities (e.g., clearing, increased compaction) or d) increased loadings from uncollected leachate during cap construction. The latter argument seems less likely since leachate had been uncontrolled for years prior to capping, and since recently reported contaminant concentrations in leachate (Table 2) (Reference 13) are less than those reported for eastern groundwater. See References 1, 12 and 13 for a more complete groundwater and leachate chemical database, including semi-volatile organics, inorganics and conventional parameters.

The water table monitoring of this study confirmed the presence of approximately 10 ft of saturated refuse under the early spring water table in the western area of the fill (landfill well JLF-1). Additional mounding analysis performed by EPA in February and March 1991 indicates a continuation of this problem. Upward vertical gradients in this area suggest that post-closure mounding may continue to be a chronic source of groundwater contamination.

E. Phase Three Remedial Activities

(1) Groundwater and Leachate Treatment

ROD III calls for extraction of southwestern overburden and eastern overburden and shallow bedrock groundwater for combined biological-based treatment with leachate on site. The southwestern extraction trench design, developed by LAW Environmental, Inc. under contract to the Corps, is currently at the 90-95 % completion stage, and should be ready for advertizing in summer 1991. The cap's southwestern sedimentation basin was relocated (i.e., a change order was implemented) to allow for improved trench access and function as compared to the conceptual location presented in the 1988 phase three feasibility study (Reference 1). The design of the eastern extraction system, on the other hand, was postponed pending the results of the 12 month groundwater monitoring study discussed above, and is just now getting underway. Once designed, however, an additional advantage to the change from leachate USTs to pump stations discussed above is that eastern extraction system construction costs and schedule should be reduced since primary voltage power will now be readily available in this remote area.

Certain PRPs are also performing on-site treatability studies as part of the AOC. While as yet incomplete, the goal of these studies is to develop an optimized, pilot study-based conceptual design for the groundwater and leachate treatment plant. The detailed plans and specifications for the plant will then be developed through the Corps.

ROD III also includes provisions for an upgradient diversion trench in the northwestern area of the site as an attempt to lower the water table within the landfill, although it cautions against the consequent potential for gradient reversal. The groundwater monitoring study discussed above (Reference 12) concludes that the trench may be ineffective at reducing the amount of saturated refuse, due to the flat gradients in the western area and the potential for inflow from rising shallow bedrock groundwater.

(2) Landfill Gas Treatment

ROD III also calls for incineration of landfill vent gas. The design approach has been to pursue gas vent manifolding (above the cap) and flaring as an initial step to allow for updated

(i.e., post-capping) gas quantity and quality characterization. This will allow for a maximally cost-effective design of the incineration unit, should the updated gas data reconfirm the need for this treatment. In this scenario, the flare would be used as a back-up treatment during incinerator maintenance or down time. Note that some PRPs have expressed an interest in pursuing a methane recovery project at this site.

Due to the significant gas flow in the leachate toe-drains, these drains will be connected to the gas manifold system. The two landfill groundwater monitoring wells will also be tied-in to the manifold. Additionally, the loaming and seeding of the landfill crest originally specified in the cap design has been transferred to the phase three design so that it may be integrated with construction of the manifold. The manifold and flare design is on the same schedule as the southwestern groundwater collection trench, and is also being developed by LAW Environmental, Inc.

Selected worst-case vent emission data from three separate sampling events (1984, 1986 and 1987) (Reference 1) are listed in Table 3. Included in this table for reference are the ninety-fifth percentile and maximum concentrations of nine carcinogenic VOCs from a 1990 California Air Resources Board (CARB) study of vent gas from 340 hazardous (n=26) and non-hazardous (n=314) landfills (Reference 14). Note that for seven of these VOCs, the maximum concentrations reported for the site are above the CARB study 95th percentile concentrations, and two site contaminants (trichloroethene and carbon tetrachloride) had maximum concentrations above the CARB maxima.

(3) Sediments

ROD III also addressed nearby stream sediments contaminated with polynuclear aromatic hydrocarbons (PAH). The ROD selected a target cleanup level of 1 ppm for total carcinogenic PAHs(e.g.,benzo(a)pyrene,benzo(a)anthracene,benzo(b)fluoranthene,benzo(k)fluoranthene, indeno (1,2,3-cd) pyrene, and chrysene), and required that additional sampling be performed during design to determine the exact extent of dredging. This design sampling, however, performed in December 1988, indicated that the PAH concentrations were at or below the ROD's target levels. Thus, this cleanup has been postponed pending further review of the sediments' toxicity.

CONCLUSION

The issues that arise during construction of a project of this magnitude are complex, time-consuming and difficult to resolve. Nevertheless, during construction components of the cap design were improved based on field observations, value engineering and coordination between the Corps, EPA and DEP bureaucracies. The level of effort required during construction by EPA and state personnel for the review of field changes, VE proposals, Potentially Responsible Party (PRP) and community relations, and general oversight may not be adequately recognized by program work load models.

Remedial decisions made prior to construction can be subject to change due to the VE process, changed site conditions, community non-acceptance and the three-dimensional realities of construction. In this instance, the operable unit segregation of leachate collection per ROD II from leachate treatment per ROD III caused difficulties in managing leachate on an interim basis. Significant changes to the construction contract were made, however, to allow for integration of these two remedies. Similarly, contract changes were made to allow for a smoother transition to the phase three gas collection and treatment remedies.

Expanded groundwater monitoring has highlighted the temporal variability of groundwater contamination, as well as the limitations of the Contract Lab Program's target compound list for sites of this type. Continued monitoring will be required to assess the exact impacts of the cap on improving groundwater contamination.

Because of the hydrogeological characteristics of this site, additional aquifer remediation beyond source control is being pursued. This aquifer clean up, as well as the other ROD III remedies, will take advantage of the lessons learned during construction of the landfill cap. Our implementation experiences should also be considered for other similar sites in order to appreciate and plan for the complicated issues that arise.

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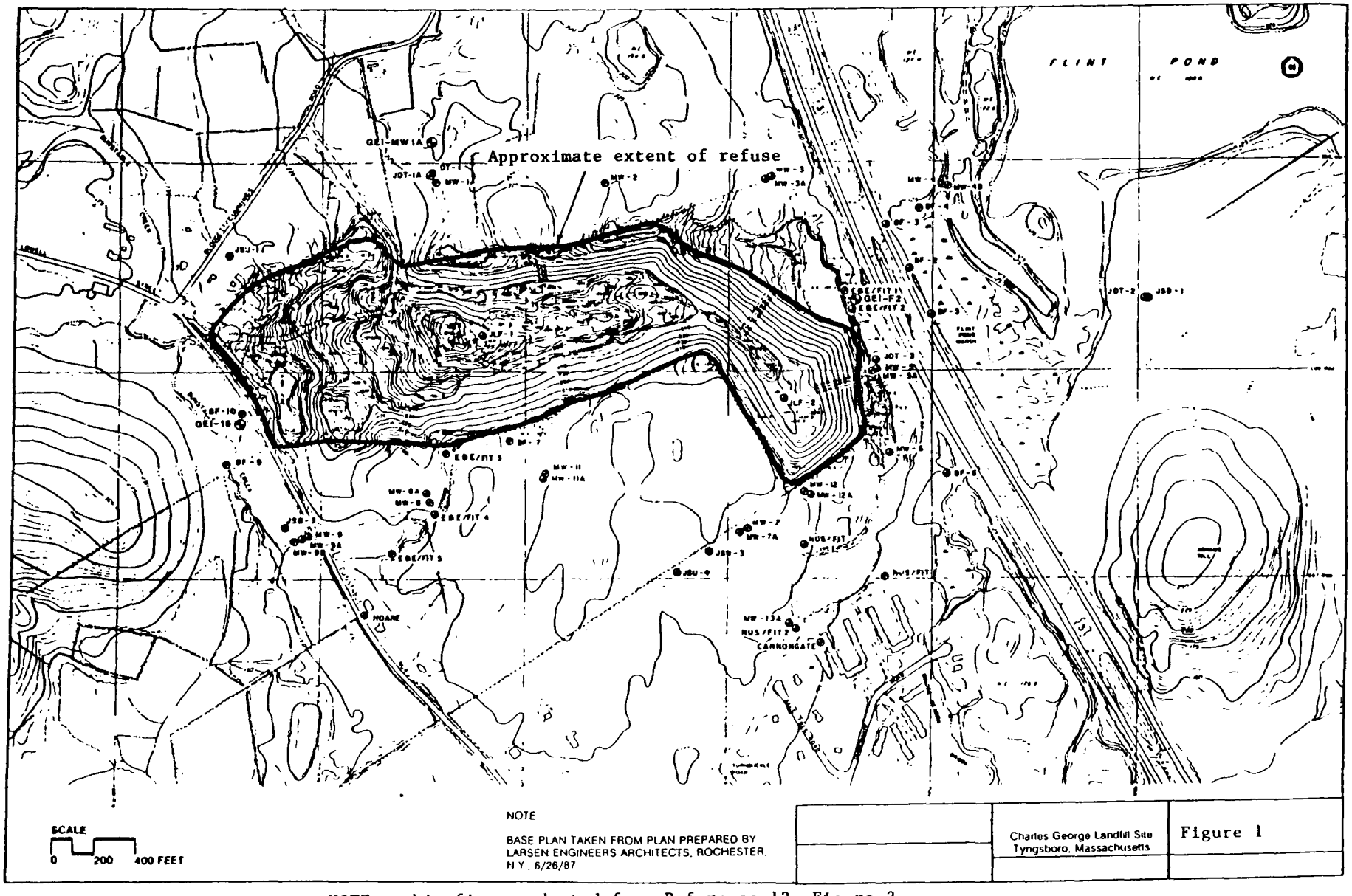


NOTE: this figure adapted from Reference 12, Figure 2.

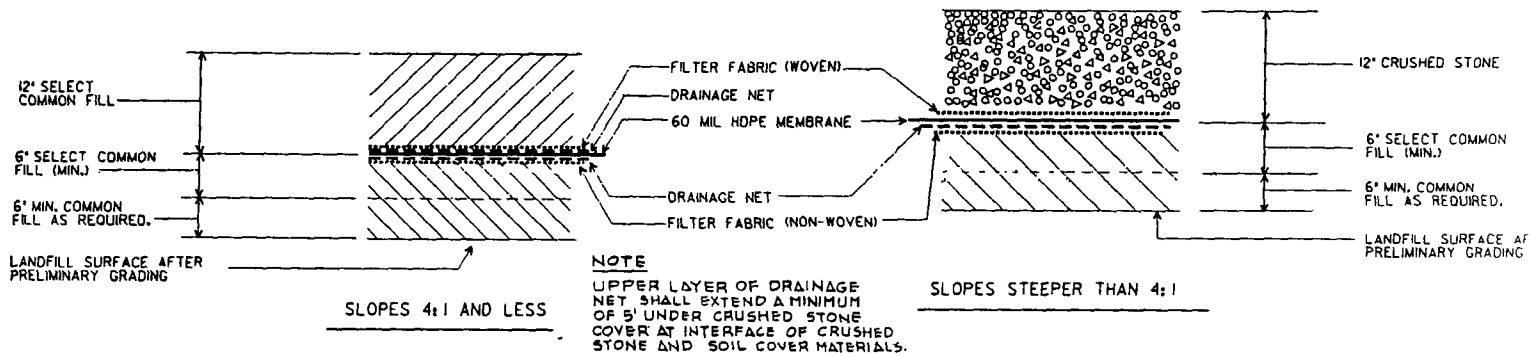


Figure 2 - TYPICAL LANDFILL CAP CROSS-SECTION DETAIL

NTS

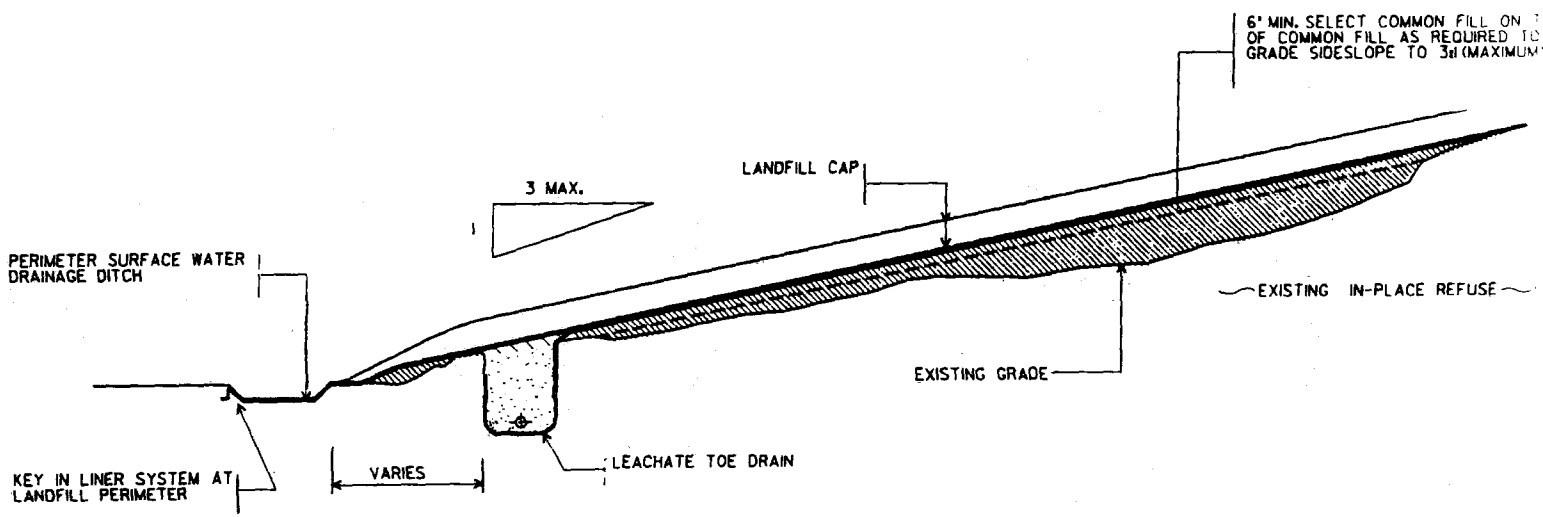
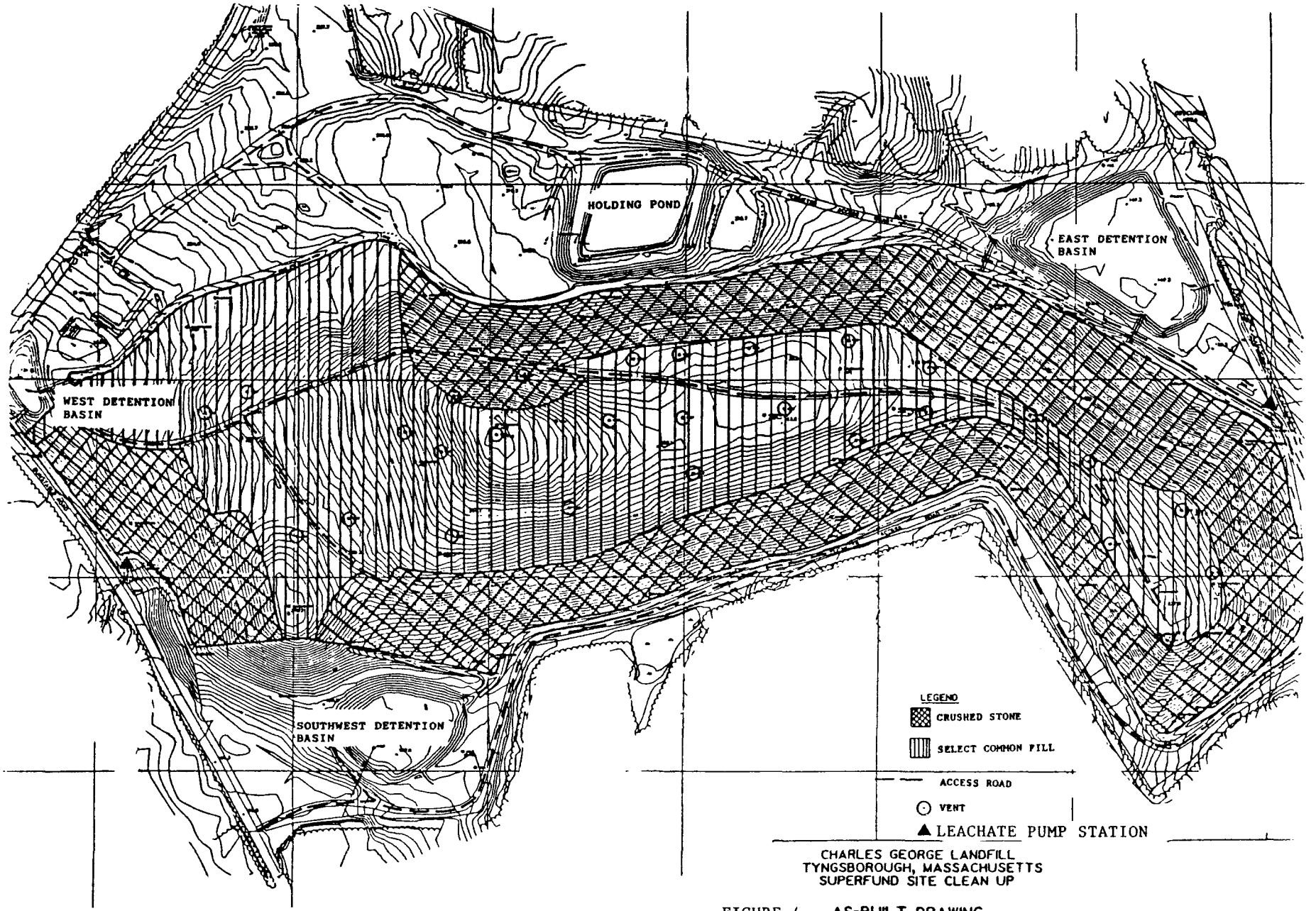


Figure 3 - TYPICAL CROSS SECTION



CHARLES GEORGE LANDFILL
TYNGSBOROUGH, MASSACHUSETTS
SUPERFUND SITE CLEAN UP

FIGURE 4 - AS-BUILT DRAWING

TABLE 1 - ANALYTICAL RESULTS MONITORING WELL E&E FIT2
Charles George Land Reclamation Trust Landfill
Tyngsboro, Massachusetts

Sample Location E&E Fit2 Eastern Shallow Overburden

Screened Interval 21.0 to 45.0

Date Sampled	Jul-84	Oct-84	Jan-85	Feb-87	Mar-89	Nov-89	Dec-89	Jan-90	Jan-90	Feb-90	Mar-90	Apr-90	May-90	May-90	Jun-90	Jul-90	Aug-90	Sep-90	Sep-90	Oct-90
Sampled by	NUS	NUS	NUS	ECJordan	NEIC	GEI	GEI	GEI	GEI	GEI	GEI	GEI	GEI	GEI	GEI	GEI	GEI	GEI	GEI	GEI
								CLP	Duplicate				CLP	Duplicate				CLP	Duplicate	
VOLATILE ORGANICS (ug/L)													*	*		*				
Acetone		J74000	R3700		14	2700		J1300	500	280	74	190	J580							660
2-Butanone			J7400	J40	12	4400	4300	J1300	1100	450	93	200	J490							
2-Hexanone	500												UJ						10	
4-Methy-2-pentanone		R4600				710		J140	110	56	11		J150					J140	170	
Benzene	560	R2400			73	670	900	500	550	500	630	1200	J1200	1900	5200	1200	1200	1400	1700	1400
Toluene	930		J550		36	820	700	J240	220	160	39	130	J120	51				J110	78	
Ethylbenzene	61	J440			71	510	530	340	420	480	630	1200	J930	1500	5900	1200	1100	1400	1700	1500
Chlorobenzene													UJ						11	
Xylenes (total)	130			6	48	290		J220	240	310	370	700	J560	870	3100	1100	670	940	1100	1100
Chloroethane										53	63	110	UJ					UJ	160	
Tetrahydrofuran	NT	NT	NT	NT		3200		1500	1300	1108	810	1600	J2600	3000	11000	2000	3200	J3000		2700
1,1-Dichloroethane	84				2								UJ							
Trans-1,1-dicloroethane	75	J960											UJ							
1,1,1-Trichloroethane								BJ170					UJ							
Carbon Tetrachloride	50												UJ							
Chloroform	50												UJ							
Methylene Chloride	J350	10000	R1300					J1100					UJ130	B54		880		U		
1,4-Dioxane	NT	NT	NT	NT							490		R					R		
Ethyl Ether													J170							

* Volatiles Analyzed Outside Holding Time

NOTE: this table adapted from Reference 11, Table C-9.

TABLE 2
CHEMICAL CONCENTRATIONS IN LEACHATE (ug/L)
CHARLES GEORGE LANDFILL - 1989
TYNGSBORO, MA

Chemical	East Leachate Lagoon March, 1989	West Leachate Lagoon March, 1989	Eastern Leachate Collection Manhole August 3, 1989		Seeps at Western Toe of Landfill August 3,1989 LS-102	Southwest Swale Area August 3,1989 LS-103	East Seep December, 1989
			LS-101	(Duplicate) LS-104			
Volatile Organic Compounds:							
Ethyl Ether	15	10	NA	NA	NA	NA	NA
Methylene Chloride	ND	ND	ND	ND	ND	NA	NA
Acetone	59	500	ND	ND	ND	NA	NA
1,1-Dichloroethane	3	ND	ND	ND	ND	NA	NA
2-Methyl-2-propanol	ND	ND	NA	NA	NA	NA	NA
Tetrahydrofuran	1200	160	550	620	16	NA	2,100
1,2-Dichloroethane	ND	ND	ND	ND	ND	NA	NA
2-Methyl-2-butanol	ND	9	NA	NA	NA	NA	NA
cis-1,2-dichloroethane	4	2	NA	NA	NA	NA	NA
2-Butanone	ND	530	ND	58	ND	NA	ND
2-Butanol	ND	ND	NA	NA	NA	NA	NA
1,2-Dichloropropane	ND	ND	ND	ND	ND	NA	NA
Trichloroethene	ND	0.54	ND	ND	ND	NA	NA
1,4-Dioxane	1200	ND	ND	ND	ND	NA	NA
4-Methyl-2-pentanol	ND	72	NA	NA	NA	NA	NA
Benzene	1	1	87	85	6.1	NA	ND
4-Methyl-2-pentanone	ND	110	ND	ND	ND	NA	NA
2-Hexanone	ND	23	ND	ND	ND	NA	NA
n-Propylbenzene	ND	ND	NA	NA	NA	NA	NA
1,3,5-Trimethylbenzene	ND	ND	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	0.87	1	NA	NA	NA	NA	NA
Toluene	6	26	260	240	ND	NA	ND
Chlorobenzene	ND	ND	33	32	ND	NA	ND
Ethylbenzene	2	3	310	260	10	NA	93
1,4-Dichlorobenzene	ND	1	ND	ND	ND	NA	NA
1,2-Dichlorobenzene	0.55	ND	ND	ND	ND	NA	NA
m- and/or p-xylene	6	7	NA	NA	NA	NA	NA
o-Xylene	2	3	NA	NA	NA	NA	NA
Total Xylenes	NA	NA	470	450	57	NA	190
Carbon disulfide	NA	NA	68 *	67 *	ND *	NA	ND

ND - Less than Limit of Detection
NA - Not Available
* - Trip Blank Resulted in 12 ug/l

NOTE: this table adapted from Reference 12, table A-1.

Table 3

Charles George Landfill Worst-Case Vent Gas Data (mg/m3)

Chemical	ECJ 1987 (a)	NUS 1986 (b) Vent 5	NUS 1986 (b) Vent 7	NUS 1986 (b) Vent 12	NUS 1984-85 (b) Vent 5	NUS 1984-85 (b) Vent 12	CARB Study (c) 95th Percentile	CARB Study (c) Maximum
tetrachloroethene	5.4	0.4		28.0	4.1	37.8	40.1	306.0
trichloroethene		0.1		60.0	0.8	77.8	14.0	59.4
methylene chloride	4.4	0.3	0.7	220.0	0.2	94.4	84.0	560.0
1,1,1-trichloroethane	0.7	0.1		4.2	0.1	6.7	12.4	518.4
benzene	7.0	0.1		9.4	2.9	17.8	11.2	1,536.0
vinyl chloride		3.0	0.2	102.0	1.8	13.3	25.5	187.2
1,2-dichloroethane	15.2			2.8		1.0	2.8	392.0
chloroform					2.0		1.0	53.9
carbon tetrachloride	26.4						3.2	13.2
toluene	94.1	2.0	2.8	128.0	280.0	222.0		
ethylbenzene	186.7	3.6	1.5	38.0	677.7	70.0		
total xylenes		17.2	10.6	82.0	177.8	170.0		
chlorobenzene	12.0	0.8	0.4	4.2	5.0	3.8		
4-methyl-2-pentanone		1.4	0.5	16.0	16.0	0.4		
2-butanone				64.0	0.6	3.2		
acetone				30.0	0.6	2.6		
chloroethane	4.7	3.4	0.7	30.0	0.4	1.8		
1,1-dichloroethane		0.1		60.0	0.5	133.3		
trans-1,2-dichloroethene		0.1		164.0	1.2	288.9		

a) E.C.Jordan Co./Ebasco Services Inc (see Reference 13 (RI), Tables 10-24 or 12-23).

b) NUS Corporation - all values are approximate (see Reference 13 (FS), Table F-2).

c) Converted from ppm as listed in Reference 14, Table 1.

II. COMMUNITY RELATIONS

BELLS AND WHISTLES: COMMUNITY RELATIONS DURING REMEDIAL DESIGN AND REMEDIAL ACTION

(Author(s) and Address(es) at end of paper)

INTRODUCTION

Many project managers are familiar with the community relations needed in order to get a Record of Decision (ROD) signed. These requirements include: remedial investigation (RI) kickoff meeting, RI public meeting, community updates, press inquiries, other public meetings and briefings and finally -- the public comment meeting on the proposed plan in the feasibility study (FS). The community relations program has successfully involved the public in the Superfund process and has become an integral part of the RI/FS.

However, as projects move into the remedial design and remedial action (RD/RA) phase, a strong community relations program should still be maintained. Two problems can arise: RD/RA community relations requirements are not as developed as in the RI/FS and, as can happen during the RI/FS process, good community relations does not necessarily mean that all community problems or objections can be adequately resolved. This paper will discuss RD/RA community relations requirements under the National Contingency Plan (NCP), why it is important to maintain good community relations, and three case studies showing varied results. Finally, it will analyze what has been learned and provide recommendations for appropriate RD/RA community relations.

The first case study will discuss a successful community relations program during remedy selection that has been somewhat stymied by an individual wanting to change that remedy. The second one will outline how poor community relations during the RI/FS has led to numerous problems in the community's accepting the selected remedy. The last one will discuss how a community initially resisted EPA actions but, based upon changes in EPA's response to community needs, now accepts and supports the cleanup. In all cases, the focus will be on the importance of good community relations during RD/RA, how important it is to build upon the success of the RI/FS program, and on numerous unexpected problems that still arise even in the best designed and implemented RD/RA community relations program.

The NCP outlines three requirements for RD/RA community relations: an announcement that EPA has signed a record of decision, an update of the community relations plan (if needed), and an opportunity for a public meeting when the design is completed.

While the Remedial Project Manager (RPM) may feel the majority of community involvement may be over as soon as the ROD is signed, that may not be the case as there may be an entirely new community dynamic at work. RD is a process that normally does not incorporate public opinion. Because the process does not have clear public participation milestones, EPA does not meet with the community regularly. Accordingly, when issues do arise, a forum does not exist for the public to communicate with EPA.

What may occur is a shift in community acceptance of the ROD, whereby what at first appeared to be a good or accepted solution, may be met with community hostility later. When information is not adequately conveyed by EPA, many other comments, points of view or recommendations may surface from external sources that may undermine the support of the ROD. Of course, just the opposite may occur. The public may have accepted the ROD and is waiting for EPA to implement the remedy.

In either case, why should EPA implement more RD/RA community relations than is required? After all, the ROD is signed. The public can't change EPA's alternative now, can it? There are two answers to that question. One is that EPA has the responsibility to keep the public informed and involved in its Superfund process. The second is that good community relations simply helps avoid, mitigate or resolve community conflicts. This selfish reason can help motivate EPA personnel to keep the public informed and involved. For either reason, the gauntlet is still placed before EPA. Active community relations is not only something that will keep the project moving smoothly--it is also the right thing to do!

CASE STUDIES

I. Case Study

A. Site Description

1. Marion (Bragg) Dump Superfund Site
2. Marion (Grant County), Indiana
3. Final on NPL September 1983
4. RI authorized in 1985 (a few samples taken in 1985); RI started February 1986
5. Originally operated as a local dump; accepted municipal wastes, and semi-solid, liquid and potentially hazardous wastes from nearby companies
6. Contaminants of concern: ammonia and inorganic compounds (arsenic, barium), polycyclic aromatic hydrocarbons - contaminating soils and ground water
7. Interim ROD (addressing surface soils and on-site wastes) signed September 30, 1987; this is Operable Unit 1 (of three; the remaining two to address ground water and the on-site pond)
8. Major elements of remedy: capping the site, regrading portions of site's surface to promote surface water runoff, fencing the site, replacing on-site wells, deed restrictions, protecting the site from Missessinewa River floods to help maintain the cap, monitoring ground water

B. Issues and special problems during RI/FS

Few citizen concerns relating to the Superfund site were recorded prior to the 1987 interim ROD. Concerns about other area dump sites were expressed to the RPM, and referred to the Indiana Department of Environmental Management (IDEM). Concern about public use of a neighboring recreational facility was referred to the Indiana State Board of Health. Media coverage was regular but not oriented toward controversy.

C. Attitude of community toward interim ROD

The RPM visited neighbors of the site and was available frequently to them, but few residents attended public meetings. Most who attended the January 1986 RI/FS kick-off meeting were homeowners living adjacent to an operating landfill. They wanted it closed and were referred to the State. They also were concerned about the possibility of arsenic in their wells and

were given appropriate advice for this concern. At the time of the ROD, the landfill they were concerned about was closed, and that group of citizens did not attend the August 1987 FS/Proposed Plan public meeting.

No comments on the Proposed Plan were received from the general public during a five and one-half week public comment period.

D. Remedial Design Community Relations

Acceptance of EPA's decision did not continue, unfortunately. A local citizen-activist, previously inactive, became active after the ROD was signed. She has maintained a volunteer leadership position in a local environmental group ever since the ROD was signed; the group vocally and industriously opposes the interim remedy. The activist's involvement is first recorded in 1988. Opposition activities read like a laundry list:

April 29, 1988 - letter from the activist to Basil Constantelos, then Director of the Waste Management Division in Region 5: she "would like the Environmental Protection Agency to hold a public hearing within thirty days ... in regards to the Marion/Bragg Dump ..." She did not fail to mention she and friends had "walked on the dumpsite," describing portions of the visit as "real gruesome, ... a mess!" Not trusting the chosen technology, she said she looked forward to receiving his reply within 10 business days and to meeting with EPA officials within 30 days. (EPA's responded that since there was no new information about the site, there was no reason to have another public meeting.)

September 12, 1988 - letter from U.S. Representative Jim Jontz to Mr. Constantelos, in response to citizen pressure, requesting a meeting about the site. Region 5 Administrator Valdas Adamkus replied that a meeting would be held.

September 16, 1988 - EPA conversation record shows that Jontz's representative thought there was "some misinformation out there," that Congressman Jontz's office did not necessarily believe the remedy was wrong or should be changed, and that he did not know why the opposition group was so late in getting involved. He requested a meeting (referenced above) with EPA, the congressman and members of the group.

Spring 1988 - letter-writing campaign to Basil Constantelos (it cannot clearly be said that the local environmental group organized the campaign) opposing the remedy, saying a clay cap was unacceptable, and that instead of a cleanup they were getting a "cover-up." Most said they expected a reply in 10 days and a public hearing in 30 days. The reply explained EPA's public involvement process prior to the interim ROD. Why the remedy would properly address contamination at the site was reiterated; the letter concluded, "... [s]ince the remedy presented in the ROD has not been changed and there has been no new information ... that significantly changes the information upon which the selection of the remedy was made, there does not appear to be any reason to have another public meeting at this time. ... [T]here certainly has been every attempt made to communicate with the community. ..." Also, "[t]he site will be cleaned up. A clean-up does not

necessarily mean that the wastes will be removed." U.S. Senator Richard Lugar, Senator Dan Quayle, State Representative Tracy Boatwright, and Basil Constantelos also received opposition letters.

September 1988 - petition drive with more than 700 signatures:

> "We demand, as an emergency measure, that a fence be constructed to prevent children, adults, and wildlife from entering the Marion/Bragg Dump. We demand signs be posted informing people that this is a hazardous waste area. We demand both actions be taken within 30 days upon receipt of this petition."

Copies were sent to Senators Lugar and Quayle, Congressman Jontz, former Governor Robert Orr, Secretary of State Evan Bayh, IDEM Commissioner Nancy Maloley, and other local and EPA officials. Signatures were gathered from Marion and neighboring communities, including Indianapolis, which is more than 50 miles away. Three local activists, including the previously mentioned one, submitted the petitions to EPA Administrator Lee Thomas. EPA's response said concerns would be discussed in a meeting (mentioned above).

October 25, 1988 - meeting! The CRC, former RPM and new RPM attended the meeting. TV, radio and newspaper media were present (probably called by the local activist group); nearly 50 residents attended. The CRC's notes said, "[w]hat was to have been a small information committee meeting turned into a full scale media event and public meeting." In the 3-hour meeting the RPMs and CRC were "questioned, drilled ... verbally abused" and "on the firing line for the remedy selected for the ROD." EPA was criticized for not keeping the public informed. The activist delivered a handwritten list of 12 questions to the CRC. (The RPM responded to these in detail.) The CRC told those present that if EPA was to revisit the ROD, a great deal of time would be lost, that the study might have to begin anew. The activist was reportedly "disturbed that [the CRC] mentioned this to the audience and demanded [he] refrain from stating this fact. [The CRC] explained ... this was the process and these were ... instructions." This meeting was held prior to a congressional election. (The local newspaper reported the meeting in a low-key way, not mentioning major controversy.)

February 1989 - community interviews for revision of the Community Relations Plan (CRP), primarily in response to the activist and her efforts to discredit EPA's decision. Many citizens expressed good will and a desire for the cleanup to progress rapidly, but the activist had contacted the press and her group, saying EPA was coming to town to discuss problems at the site with her. As a result, an article appeared in the local paper the day before the interviews, saying a meeting was scheduled with the activist, that she "planned to talk to other environmentalists before the meeting so they could help her plan for it," and that "[h]er organization disagrees with the EPA's ... cleanup plan."

February 2, 1989 - follow-up article quoted the CRC as saying, "We're here to find out how we can best convey the information to the public," and that EPA requested of the activist and her group "if they would be willing to come up with a list of residents to whom information might be mailed in the

future." The activist told the reporter, "I think they ought to get off their butts and do their job. They shouldn't be here asking me to do their job for them. It's up to them to see who should be getting the information."

September 1989 - approximately 100 form letters sent by citizens to Adamkus (copies to Lugar and Coats), protesting the remedy, and saying EPA had not done an adequate job in the RI and had shown a "callous disregard" for community health. Mary Gade, Associate Division Director, Office of Superfund, responded, saying there was no new technical data indicating the remedy needed to be reconsidered. She reiterated EPA's public involvement process, and responded to each point in the letters.

October 19, 1989 - EPA meeting to announce the beginning of RA. Thirteen people signed in (including three EPA officials, two IDEM officials, the congressman's representative, and the City of Marion Community Development Director). The activist, her parents (who live in Marion) and another representative of the environmental group attended. She opposed the cap, and voiced concerns about ground-water quality and possible migration of contaminants. Reportedly, she did not clearly elaborate, but did assert resentment toward EPA for not keeping residents better informed. EPA held a press conference after the meeting.

November 13, 1989 - another meeting requested by the congressman's office. Locally generated publicity indicated this would be a "public meeting." Less than 20 people attended, several of whom were EPA or Indiana officials. Two activists attended from outside Marion; they had been involved with the environmental group and begun attending site-related meetings. Opposition was again raised to the remedy; they called it "Mickey Mouse." (Prior to this meeting, EPA had received a letter from Lugar and Coats, requesting information. They were told of the meeting, and of EPA efforts to ensure the remedy was appropriate and properly constructed. They were informed EPA had told the public EPA would "like to set up availability sessions approximately once a month in Marion while work is going on at the site.")

January 23, February 21 and March 20, 1990 - meetings to keep the public apprised of construction activities, attended by about a dozen people each.

April 25, 1990 - group tours outside the perimeter of the site, attended by more than 30 persons, and several members of the media.

At two of the meetings, the activist handed lists of 27 more questions for the RPM to respond to in writing. At all meetings, she hammered out questions and challenged the remedy. On the April tour, the two non-Marion activists attended, went on every tour (though tours were by sign-up only), dominated questioning, and confronted EPA personnel in front of the television camera. A 10-foot banner was hung on the site fence; it read "Water Pollution Happening Here" in bright-red letters. The CRC and RPM were asked if they wanted to pose with the banner for a photograph to be used on postcards.

Throughout - letters sent to various officials, including a Freedom of Information Act request from the activist. In EPA's opinion, they were responded to promptly and thoroughly. The consistent EPA response outlined how the public had been kept informed, where the public information repository was, and how the public could get more information.

August 21, 1990 - meeting regarding the proposed consent decree for site cleanup, finally lodged July 20, 1990; public comment ran for 60 days (extended on public request). EPA wrote and mailed a fact sheet, and locally placed an advertisement announcing decree's lodging (neither required for this DOJ action). The RPM also called the activist as soon as he found out what day the Federal Register notice was published. The CRC, RPM and EPA attorney were at the meeting, attended by approximately 40 citizens. Though the remedy was not to be on trial, most people did not understand that, or else did not accept it. Lots of hostility, derision and challenge was directed to EPA's representatives, including from the non-local activists. (They video-taped this meeting, as they had all other meetings.) Public comment was voluminous, primarily relating to the remedy and/or ROD. (The Department of Justice (DOJ) will, in this case, respond to comments about the ROD in a public document.)

As of this writing, the cap on the site is complete and RA is almost finished. A major flood swept Indiana this winter, and covered parts of the site; the cap held up very well, with need for minor repairs. When the activist was told this, she replied, "Well, what about the next flood, or the next one, or the next one?" She also wondered when the next meeting would be held.

E. Community Relations Results

Clearly, this site has caused overwhelming consternation to certain members of the community. The results of CR activities, in spite of producing considerable quantities of information and using great amounts of time and energy, and (according to whispered assertions) making many townspeople pleased with what's being done at the site (and reportedly tired of the activist), have not served to accommodate the activist or her group's demands. And, because she has had considerable contact with her congressman, unusual numbers of demands for meetings and information have been placed on EPA. EPA has stood by its decision throughout, which has made it difficult to implement effective CR activities for the broader community.

F. Analysis

It would be difficult to propose that something different could have been done before the ROD to improve community relations. EPA personnel who got involved after the ROD have been constantly met with derision and challenge. Also, it has become known that even though the opposition is outspoken, they do not necessarily represent a majority opinion. The Spring 1990 tours were particularly helpful in highlighting what has been done on site, giving ordinary citizens information and a look at the work.

Perhaps this inflamed the opposition. An activist with the tenacity, grit and sole-purpose nature of the Marion activist can become a

formidable adversary, even after the ROD has been signed. Even so, her concerns and questions are taken seriously and responded to in the best way possible.

Perhaps the best thing that can be done at Marion (Bragg) is to continue to respond to requests for information, to keep members of Congress informed, not only of what is happening at the site but how EPA is responding to constituents' concerns, and to develop creative ways of reaching the rest of the public. The tour was one such effort. EPA efforts must be more than just reactive or responsive, though.

Public meetings will continue to be held, to keep faith with EPA's statement that they would be held regularly. It is important to continue keeping the public informed, even "overinformed," and to be available as often as is practicable.

Finally, it must be remembered that good community relations does not necessarily convert all people to EPA's point of view. At this point, EPA is not trying to convince the activist that the remedy is proper, nor that she should accept it. EPA has decided, based on the best scientific evidence available, that its decision is the best one for the site.

II. Case Study

A. Site Description

1. Westinghouse Sites, Bloomington IN. Consists of 8 sites: 6 covered under a consent decree (4 NPL, 2 non-NPL) and 2 removals
2. 7 sites located in Bloomington, IN and Monroe County; one site located in Owen County, east of Monroe County.
3. 4 NPL sites final between September, 1983 and June, 1986.
4. RI never completed (see Section B).
5. Five of the sites are closed landfills; one is a former sewage treatment plant; one is a salvage yard; one is an operating factory.
6. Contaminants of concern: more than 650,000 cubic yards of PCB-contaminated materials (soils, capacitors, sewage sludge, stream bed sediments)
7. There was no formal ROD for this site. The Enforcement Decision Document was signed in December 1984; this provided the basis for the consent decree that was signed at the same time.
8. The consent decree requires that the responsible party, Westinghouse Corp., undertake a number of interim measures to reduce any further migration of PCB's into the environment (i.e., cap the landfills, clean stream beds, monitor the sites). Once completed, Westinghouse is required to construct and operate an incinerator for 11 to 15 years to destroy the entire amount of contaminated materials.

B. Issues and special problems during RI/FS

As stated previously, this site did not have an RI/FS prepared for it or a formal community relations programs. EPA Region 5 first became aware of a PCB problem in Bloomington in the mid 70's prior to the passage of Superfund. At the time, the only legal authorities available were the Clean Water Act and the Toxic Substances Control Act (TSCA); neither of these had jurisdiction to require Westinghouse to pay for the PCB cleanup. By late 1980, EPA legal and technical staff had developed an enforcement case against Westinghouse for PCB contamination at two of the six consent decree sites.

The Superfund law passed in late 1980 and EPA shifted its case, filing a Superfund complaint against Westinghouse. Concurrently the City of Bloomington and the County of Monroe filed suits for two other non-NPL sites.

Because of the ongoing litigation and because there was no formal EPA guidance on how to conduct an RI/FS, EPA did not do an "official" RI/FS for these sites. Rather, the team of experts and litigation witnesses conducted a number of studies that identified the problems and proposed solutions. Much of the rationale and decisions made regarding alternative selection was conducted through review by experts and meetings with the litigation team. Consequently, much of the decision-making process or alternatives assessment was not documented. The primary reason for this was that EPA was uncertain if this case would go to trial, so the information was considered "enforcement confidential."

Finally, because the Superfund enforcement program was new, there were not the formal procedures which are now in place to conduct RI/FS's at responsible party lead sites. Rather, EPA prepared an internal Enforcement Decision Document which outlined its negotiating position in case EPA were to go to trial. Therefore, no formal Record of Decision was prepared at these sites nor was there a formal community relations program in place during this time.

The result of all these studies and internal discussions was that EPA's Superfund case was joined by the City's and County's cases and taken to Federal District Court for trial. The judge required the parties to negotiate with Westinghouse to reach a settlement. The major parties - U.S. EPA, the City of Bloomington, Monroe County, the Indiana State Board of Health (the former Environmental Division is now the Indiana Department of Environmental Management which is now called IDEM) and Westinghouse - spent more than 18 months working on a settlement.

By December 1984, the parties reached a settlement which required Westinghouse to construct an incinerator to destroy all the PCB-contaminated materials at 6 selected sites which contained the majority of the PCB contamination in Bloomington and the surrounding area - more than 650,000 cubic yards of materials. In order to make the incinerator financially viable for Westinghouse, the parties agreed that the fuel used would be the city's municipal waste stream. It was also agreed that the incinerator would be used only for this purpose and would operate for 11 to 15 years. Four of the sites

were on the NPL; the other two were added at the request of the City and the County to reduce their liabilities to clean up those sites.

This agreement was filed in Federal Court and subjected to a lengthy public comment period, from December 1984 to August 1985. More than 15 public meetings and information forums were held by EPA and the City of Bloomington regarding all aspects of the consent decree. Despite numerous comments opposed to the incinerator and the closed manner in which the investigation and alternatives array process was developed, the consent decree was lodged in Federal District Court in August 1985.

In spite of the court ordered decree, progress has been exceedingly slow in implementing its terms. Westinghouse has implemented a number of the interim measures but has been slow in designing and constructing the incinerator. Additionally, Monroe County officials had raised some legal issues that were time-consuming to resolve, and there has been a general slowness by all of the parties to put together achievable schedules. In large part, EPA was hampered by the lack of a full-time RPM and CRC devoted to the site to insure that the project stayed on schedule. All this occurred from mid-1985 to mid-1988 when EPA finally assigned a full-time, more experienced RPM to the project.

Also, by 1989, all the consent decree parties were meeting quarterly to discuss site problems and come up with solutions. By December 1990, EPA had negotiated an implementation schedule with all consent decree parties. It outlined the submittal of permits, review and approval time, public involvement steps, the timing for incinerator construction, test burns, final approvals and actual start time for the incinerator.

C. Attitudes of community toward ROD

To this day, the community believes that it did not have adequate opportunity to participate in the process to properly identify the problem (it believes much more contamination exists), to look at possible solutions (it is opposed to incineration and wishes it could have discussed alternatives), and to have their voices heard in opposition (it felt the consent decree was a "done deal" and public comment had no impact upon it).

During the negotiations and intensifying during the public comment period, numerous local groups directly attacked EPA as doing a poor job in protecting the interests of Bloomington residents. The majority of protestors and public comments were from college students, a fair number of "counter-culture" individuals, university professors, and local branches of national environmental and civic groups (League of Women Voters, Audubon Society). There appeared to be very few comments from the average Bloomington resident who may have felt the problem affected some persons on the other side of town (most of the sites are located in poorer sections of Bloomington).

It appeared that very few persons were aware that the plan called for incineration and what incineration would mean to Bloomington.

From mid-1985 to now, the most vocal local group opposed to the construction of an incinerator is People Against the Incinerator (PATI). From

their previous statements and physical appearance, PATI is perceived as a "counter-culture" group and receives little credibility from most Bloomington residents. PATI has approached Region 5 and Headquarters numerous times over the last six years to complain about: the remedy, the lack of an RI/FS, mixing municipal solid waste with PCBs (because it believes it is an unproven and dangerous incineration technology), and the lack of public involvement in the decision-making process. PATI is also affiliated with and an active supporter of Greenpeace Action and other nation-wide groups that are opposed to incineration.

By mid-1989, IDEM determined that ash from a hazardous waste incinerator must be disposed of in a special waste landfill which must meet the same requirements as a hazardous waste landfill. The Federal judge required Westinghouse to identify a location for that landfill in Monroe County. This meant that no longer would the ash be disposed of near the incinerator as originally outlined in the consent decree but that the ash would be transported to another location in the county. By early 1990, rumors circulated that Westinghouse had found a location in a geologically appropriate location north of town (In spite of the fact that Monroe County consists primarily of a porous underground structure called karst which cannot be used for landfills). A number of the residents in that area formed a group named Coalition Opposed to PCB Ash in Monroe County (COPA).

COPA consists of business persons, nurses, service sector persons and others heretofore not associated with this issue. COPA also has considerable support from a wealthy resident whose home overlooks the location for the proposed landfill. COPA has been trying to raise the community's consciousness regarding the consent decree and the impact it will have upon the community. Letters to the editor from COPA members have been published in the newspaper, it has published a 11-page brochure, placed billboards and posters in town, and even produced a 30-second television ad alerting Monroe County residents to what it feels are problems with incinerating PCB's with municipal solid waste. Based upon newspaper coverage and comments related directly to this author on numerous occasions, they have been successful in alerting many members of the public to this issue.

COPA has been effective in contacting State and Federal politicians and working with them to stop the incinerator, and trying to reopen the consent decree. Due to COPA, a recent bill was introduced and passed through both chambers of the Indiana legislature that would effectively block construction of the incinerator unless the local County solid waste management district approved of it. If the Governor signs the bill and if the county solid waste district does not approve the incinerator, this could pose a major roadblock to construction of the incinerator.

Also, pressure from COPA has already been influential in the mayor's race. The current mayor, who signed the consent decree in 1985, is now lobbying EPA headquarters (HQ) for a change in TSCA's PCB cleanup rules to allow the city more latitude in dealing with PCB cleanups. The mayor has attacked Westinghouse's proposed technology as inadequate for health protection even though she supported it previously. Her opponents have accused her of using this as election year grandstanding.

The best way to characterize the current level of community attitudes towards the consent decree is that it has been "de-radicalized." The entire issue of incineration, PCB control alternatives, hazardous waste landfilling, the consent decree, and all associated topics have been topics of newspaper editorials, television and radio shows, speaking engagements at civic and public service clubs, and other public forums. The public feels the consent decree approach is inappropriate and another alternative besides incineration should be pursued in Bloomington.

D. Remedial Design Community Relations

Since remedial design for this site actually started after the official lodging of the consent decree in Federal Court, EPA has a long history of community involvement. Immediately after the consent decree was lodged, EPA attorneys believed that community relations would be conducted locally, and the city and county would establish a community relations program. However, this did not happen and site-information gaps occurred. EPA did send out sporadic fact sheets and press releases covering a number of the interim measures from 1986 to 1988. Without a strong presence, however, EPA did a poor job of communicating its actions and responding to community criticisms of how the interim measures were completed.

At the same time, EPA was receiving a steady stream of letters to the HQ Administrator and Regional Administrator complaining about EPA's so-called illegal actions and the lack of public involvement in the decision-making process. Recognizing this as a problem, a Public Information Center was established in January 1989 in Bloomington to be an information conduit to the public and to receive public input on the project. It is also an ideal way for EPA to monitor public opinion by tracking telephone calls and newspaper articles. Finally, the office allows EPA to be apprised of events in the community.

EPA staff use this office when visiting the community to arrange meetings with concerned individuals, brief elected officials, and by holding press conferences on key announcements. Having a local office facilitates EPA staff in responding to questions and following up on information requests when making public appearances in Bloomington. Also, based upon the numbers, types, and frequency of phone calls and walk-in visitors, it appears that community members find the local office beneficial in recieving information from EPA as well as sharing their views with the local office. EPA's CRC and RPM keep daily contact with the contractor staff in the office.

By summer 1989, EPA had a request from PATI to start a Citizens Information Committee (CIC) that would meet monthly to communicate with residents about what is taking place at the sites in town. EPA agreed and chose a representative sample of individuals and groups to be on the CIC. It has been meeting since November 1989 and, while it has taken some time for it to find its focus, it has proved to be a valuable communication technique for EPA and the CIC members. CIC meetings have discussed, among other things, pros and cons of incineration, Indiana requirements for hazardous waste landfills, and a proposed schedule for incinerator and landfill construction.

It has allowed EPA and the public to discuss various consent decree issues in a cordial and informative manner.

Community relations plans have been prepared for the consent decree and removal sites. Future community relations will include the monthly CIC meetings, response to community requests for speaking engagements, and development of fact sheets for the community at large. EPA will continue to foster and maintain strong press relations so that EPA can get coverage of our activities.

E. Community Relations Results

As EPA has increased its presence in the community, it has improved its ability to communicate with residents. Previous communications with EPA were done via telephone or letter. With an office staffed by contract personnel, people drop by regularly to pick up fact sheets, EPA policy guidance, EPA reports and other information generated during the course of investigations.

Equally important is the image that EPA projects in Bloomington. As the issues have increasingly entered the public forum, EPA is there to respond to them with as much information as possible. EPA is no longer surprised with announcements since local office staff are there to pick up the information as soon as it is available. Based upon comments directed to one of the authors, EPA has become somewhat trusted as a knowledgeable member of the community and not perceived as "carpetbaggers" who come and go without sensitivity to the community's needs. Also, because EPA has committed to the monthly CIC meetings, EPA is perceived as a viable party to the consent decree.

However, this does not mean that EPA's position is accepted in the community. The community interpreted EPA's incineration implementation schedule as a "war-cry" inciting it to mobilize its resources in order to stop the incinerator.

Even with that type of response, EPA still recognizes that the public demands and expects as much information from us as possible, and it is our duty to supply it.

F. Analysis

Overall, community relations at this site have gone from terrible to good in that disagreements still exist but now there is a regular forum to discuss those. Because of this site's early history, there is still considerable antagonism towards EPA and the other consent decree parties. After all, an RI/FS was not done and pre-ROD public participation guidelines were not followed. As a result, the public thinks the consent decree should be null and void. That is quite a hole that EPA needs to dig itself out of.

Being aware of that negative perception, EPA's goal is not to try to change the remedy, but to acknowledge the community's concerns. At the same time, EPA firmly believes what it has done is neither illegal nor invalid, and that it will proceed with the cleanup.

The local office and the CIC have provided a communication avenue to the community. They have provided a new array of individuals to talk to in a non-threatening and informational forum. They have raised EPA's presence and credibility in the community, and allowed EPA to provide much more information to the public than ever before. EPA is well aware that many negative perceptions continue. The goal, however, is not to try to change minds or even to influence local decisions, but to simply provide information so the public can make its own decisions.

This is never an easy task. Many times EPA personnel can be intimidated by arguments made or by charges leveled in the newspaper. Oftentimes, without a community relations plan that sets a context for EPA's activities in a community, the RPM may not respond to complaints or charges, and EPA is viewed as evasive. In this case, with a strong local presence and knowledge of all the events occurring, EPA is in a position to aggressively identify issues, make statements, or respond to charges in a positive manner. While this level of effort cannot be afforded at every site, in Bloomington, IN, it has proved to be money well spent.

III. Case Study

A. Site Description

1. Seymour Recycling Superfund Site
2. Seymour (Jackson County), Indiana
3. Final on NPL September 1983
4. RI started August 1983; RI report issued May 1986
5. Originally operated as recycling and disposal facility for chemical wastes; 50-60,000 55-gallon drums and 100 large tanks, all containing chemicals, found on site.
6. Contaminants of concern: Ground water - shallow aquifer highly contaminated with more than 90 different hazardous organic chemicals, including 1,2-dichloroethane, benzene, vinyl chloride, & 1,1,1-trichlorethane. Major portion of the contaminant plume extended approx 400 ft. from site boundary; lower concentrations of organic contaminants found as far as 1,100 ft. from boundary. Soils - hazardous organic and inorganic chemicals (>54 identified, including high concentrations of 1,1,2-trichloroethane, carbon tetrachloride, 1,1,2,2-tetrachlorethane, & trichloroethene; and low concentrations of inorganic compounds - lead, arsenic, beryllium). Surface water & wildlife contamination - contaminants reached East-West Creek.
7. ROD (addressing contaminated soil and ground water) signed 9/30/87
8. Major elements of remedy: Major elements of ROD - (1) On-site building demolished. (2) Soil vapor extraction system to remove volatile organic chemicals. (3) Nutrient application to soil to promote biodegradation of contaminated soil. (4) Multi-media cap. (5) Ground-water pump and treat system to prevent further contaminant

migration and clean up contaminated ground water. (6) Remove one foot of contaminated sediments and placed under multi-media cap. (7) Seal residential and business wells in Snyde Acres. (8) Dispose of other on-site materials. (9) Restrict access to and use of site. (10) Monitor ground water and air. **NOTE: As a result of public comments and information obtained during negotiations, EPA revised the recommended remedy.** Changes - (1) Soil vapor extraction (SVE) system modified to use horizontal rather than vertical pipes. (2) Ground-water extraction system modified to use two off-site extraction wells, in addition to the plume stabilization well system already on the site (rather than four on-site extraction wells, one on-site injection well, and one off-site extraction well). Ground water would not be pumped from the deep aquifer unless contaminant concentrations at site boundary found to be above cleanup standards. (3) Design of multi-media cap was changed. (One layer eliminated, synthetic liner made thinner, slope reduced).

B. Issues and special problems during RI/FS

A 1984 community relations plan recounts concerns of the public, discovered during community interviews prior to the start of the RI. Residents of Snyde Acres, a subdivision threatened by ground-water contamination, were particularly concerned about health risks. They felt the community had not received adequate or consistent information. Also, since studies and tests had been conducted for years, they thought cleanup should start.

The Seymour Chamber of Commerce showed interest very early in the site's history. It felt the site was an eyesore in the middle of prime industrial property, and a deterrent to new business.

The Chamber organized a task force to study options for cleaning up the site in the late 1970s. In 1980, local residents formed an ad hoc group to bring public attention to the site and make information available, maintain pressure on regulatory agencies responsible for action, and support a proposal to provide City water to Snyde Acres residents (accomplished in 1985). Media attention and public scrutiny intensified when fumes released hazards of unknown toxicity into the air in March 1980. The media reported that about 100 nearby residents were temporarily evacuated from their homes.

Although residents' concerns about the threat of explosion or fire at the site were allayed with a 1982 surface cleanup, their opinion of EPA remained low because of the following perceptions:

* EPA delayed the cleanup;
* 1982 subsurface investigations were inaccurate or incomplete;
* EPA and the State had done little cleanup work;
* Potentially Responsible Parties were responsible for cleanup success;
* EPA did not support use of settlement monies for City water hook-up to Snyde Acres (in fact, EPA and DOJ did not oppose this);

* EPA was not communicating well with the public.

Accurate and consistent communication with the public, telling people what was going to happen and when, sharing information with the Task Force at least monthly (for dissemination to other interested parties) and providing three information repositories (at the Chamber, City Hall and the library) were requested of EPA.

Seymour's mayor had a poor opinion of EPA's communication with the public, and suggested better and more regular information. The League of Women Voters suggested more efforts be made to directly involve the public.

Media coverage abounded. The New York Times covered an October 1982, $7.7 million, court-supervised agreement with PRP's. The Indianapolis Star reported on U.S. House Public Works Committee hearings on the cleanup at Seymour (called a "case study" by the Committee's Chair; he wondered "....why it took years to get federal action on the site and why local citizens could not get state of federal officials interested.") The Chicago Tribune and the Milwaukee Journal reported the controversy as well.

Considerable correspondence from the executive vice president of the Chamber (the EVP), dating from 1984, while expressing appreciation for the water hook-ups to Snyde Acres, reported growing local frustration at a lack of current information. In response, a regular and frequent series of updates/fact sheets was begun to keep the public informed of EPA activities.

October 1984 - correspondence from the EVP expressed concern about potential danger from contamination in deep wells at the nearby Elks Club, a desire for City water to be extended there, and displeasure with the proposed timetable for the Remedial Investigation report and Feasibility Study. This letter was copied to the U.S. Senators and Representative, and other officials. EPA explained that extension of water was being considered and that EPA was trying "to complete the RI/FS in the shortest timeframe possible without jeopardizing the thoroughness and accuracy of the studies."

August 14, 1985 - the EVP again wrote EPA Regional Administrator Adamkus:

> "First, we do have a surface clean up and city water to Snyde Acres, but not without having to push, prod, threaten and fight for every inch of progress that was made. ... [A]nd of all the promises the EPA has made, not one time, in my memory, have they ever got something done on time or when they promised it. That leads me to believe your people are very inefficient and/or your subcontractors are inefficient and unproductive. ... We consider the subsurface problem at SRC to be a most important community problem and the continued wasting of time is irritating, dangerous, and unhealthful. Therefore, we are asking for your personal commitment to speed up the evaluation procedures of the groundwater testing... Our desire is to get this whole problem behind us so we can leave you and your people alone to address other problems..."

By this time, Congressman Lee Hamilton was writing EPA, concerned about the delay. EPA's response said all necessary steps would be taken to minimize the delay as much as possible.

January 1986 - the EVP wrote Judge William Steckler, who would decide on EPA's request for an extension for the RI. He said he believed EPA was acting irresponsibly and requested that the judge "get tough" with EPA. The judge said he understood the community's frustrations and need for information, and responded by saying he believed the request for an extension to complete the RI/FS was needed and was made in good faith and in the best interest of the public.

June 1986 - the EVP expressed to EPA his perception, from reading the RI, "that we have some serious problems in every aspect of the investigation," but that he had "every intention of waiting for" the FS, due in September.

Further community anger and frustration is not documented beyond the last 1986 letter.

The Phased Feasibility Study (PFS - to evaluate an interim remedy for ground-water contamination) was completed in August 1985; public comment was accepted from August 15, 1986 to September 8, 1986. A public meeting was deemed unnecessary for the PFS because completion of the final FS was due September 1. The final FS was completed August 29, 1986, public comments were accepted September 13, 1986, to October 24, 1986, and the ROD was signed September 30, 1987.

C. Attitude of the community toward ROD

By the time of the October 1986 proposed-plan public meeting, community anger and vociferous concern had quieted significantly. It is interesting to note that the first person to speak from the floor was the Chamber's EVP. His first statement was in thanks to EPA for having the meeting, and for an excellent presentation. He asked several questions of fact throughout the rest of the meeting. Some Snyde Acres residents asked questions about the value of their homes, about health effects for residents and about possible side effects of the remedy.

Other questions related to the funding of the cleanup (especially as costs might affect the City in the future), and to the capacity of the City's water treatment works to handle pretreated discharge from the site.

At no time did anyone angrily challenge EPA or the speakers.

October 20, 1986 - the EVP wrote Adamkus, expressing appreciation to EPA staff for "an outstanding presentation" and stating that the Chamber of Commerce accepted the proposed remedy. He encouraged EPA to do things as expeditiously as possible to get started on the cleanup. He also requested a listing of activities and a timetable.

The League of Women Voters sent a letter expressing appreciation for the meeting, saying it was the best one ever held in Seymour. They also expressed an understanding of the decision-making necessary to choose a remedy.

The Responsiveness Summary for the PFS recorded the submittal of two letters from the public in favor of the remedy. The Responsiveness Summary for the final FS recorded no comments from the general public, other than those made at the public meeting.

The opinion of one news reporter, spoken to this author, is that public opinion improved dramatically after the ROD was signed, in part because of the excellence of EPA's public presentations.

About 14 people attended a public meeting on August 31, 1988, about the proposed Consent Decree (to record who would conduct and pay for the remedy). About 110 PRP's joined in the Decree, creating a trust fund to manage and pay for the cleanup. (About $16 million had been accumulated at the time of the public meeting.) In the agreement, the City agreed to treat the site's pretreated, discharged water; to perform routine cap maintenance; to finance two per cent of the cost of repairing the cap should it fail; and, if the public treatment works were to become unavailable for treatment of site discharge, to pay 15 per cent of the additional costs of treatment.

Near the end of the meeting, after several technical questions had been asked, as well as questions as to how the public would be kept informed, the EVP said he was pleased with the consent decree, but not without acknowledging that getting to that point was a long and arduous task, and that a lot of patience had been lost in the process. He also said that although a timeline had been proposed, based on past experience he expected it not to be met. Congressman Snores, and Senators Lugar and Quayle, concurred with the EVP.

September 1, 1988 - the EVP wrote a letter to the CRC, congratulating him and the RPM for running a smooth public meeting. He restated his support for the remedy and said he thought the public was pleased.

The tide had turned!

D. Remedial Design Community Relations

EPA has continued to make information available to the public, though the frequency and regularity of written updates has diminished during remedial action. Since February 1990, regular updates have been sent to the local cable channel, where time has been purchased on a news program. The update is read as a news story; every other time the story is accompanied by video footage.

The latest public meeting was in March 1990. About 15 residents attended. Letters, phone calls and complaints have been virtually non-existent since the ROD was signed.

An important aspect of community relations in Seymour has been the work of the Seymour Trust, and its Trustee, Monsanto Corp. An information center has been set up at the construction site, with documents and a large photo display for viewing, and personnel available for questions. The center is an impressive effort by a PRP willing and able to provide the public with detailed yet accessible information. A small tower has been built outside the exclusion zone that can be used to view the site. While the Trustee manages this, it has greatly enhanced EPA's community relations efforts.

E. Community Relations Results - outlined throughout

F. Analysis

The vigorous (even if perceived as belated) response of EPA to demands for attention by the public and local officials helped convince Seymour residents that the work being done, and the way it was being done, was the best way to accomplish a long-term remedy that would best serve public health and the environment. The EVP, a battering ram at times, demanded response, but also served to make citizens aware of what was happening. The reasoned (though occasionally vitriolic) content of his communication provided a venue for response and action.

That EPA did respond, acknowledging the sense of demands (in particular for information), and went along with local requests (such as for three repositories and more than normal numbers of written updates), probably added to the credibility of the Agency.

But the contribution of local City officials (such as the City's attorney who worked so hard on the Consent Decree), and more than cooperative trustees, especially Monsanto Corp., must be acknowledged as crucial. Only with the cooperation of all parties were community relations efforts successful.

Although "success" cannot always be measured by how well or how much the public accepts the remedy, or how good they feel toward EPA, at the Seymour Superfund site, "success" can incorporate these elements. Over the many years of activity, public perception of EPA's role changed perceptibly. Initial negative feelings were repeated at the public meeting, and EPA was not allowed to forget it was considered slow from the start. But those factors were not allowed to negatively affect the perception of a remedy and a Consent Decree designed to protect health and the environment. RA has gone smoothly ever since.

IN CONCLUSION...

While many might think that what the authors are about to say is obvious, it bears noting that the following must be understood when facing a community during RD/RA.

First of all, community relations never ends at a Superfund site. While adequate to good community relations activities might not produce the results EPA personnel would want, too few, inappropriate, or poorly planned activities will never result in positive community relations. This is true during RI/FS, as well as post-ROD.

But, as RD/RA differs from RI/FS, so do community relations differ for both phases of Superfund work. During RI/FS, a decision is led up to, and finally made. Community relations during that time focuses on making information available and involving the public in the decision. During RD/RA, the dissemination of information is still important, but later challenge to the decision can happen, in which case an expanded sense of how to keep the public involved is needed.

The goal, however, is not necessarily to get people to accept the ROD. That would be nice, always, but if EPA's process has been thorough and of high quality, then the ROD will stand and some members of the community may stay frustrated. EPA personnel must stay sensitive to that, but not let it keep them from proceeding with RD/RA. After all, especially if opposition borders on harassment, or does not truly represent the community at large, it must be remembered the remedy is designed to protect human health and the environment. That may be the most important message EPA can send: the EPA personnel working in a local community are there because they want to and are mandated to serve the public.

As much as some may not believe this, a single person can create a movement in opposition to a remedy that can all but derail work at a site. Work will go on, of course, demands for information (bordering on minutiae), FOIA's, public attacks (including personal attacks), form letters, petitions, ad nauseam, can make EPA personnel wish community relations requirements would evaporate (perhaps accurately supposing that more opposition is in store).

Also, many people want to believe misinformation. If it is presented by a voice that has developed its own credibility ("I was talking with the Senator when I was in Washington, and he told me..."), then EPA will have quite a job countering what is wrong, with what is correct. "You're a bureaucrat, and..." has been thrown at many RPM's and CRC's, as we all well know.

Some recommendations can be made. First of all, remember that, while we all have individual limitations, if we have done our job accurately, thoroughly and to the best of our abilities, we must not take attacks personally. Some people may try to launch personal attacks, but, since we can be secure in the quality of our work, attacks cannot be allowed to color our willingness to respond to the community's needs. We are government representatives and, as such, often are not trusted. If this is understood

from the outset, we can actively work on creating a public face that is worthy of trust for those who rely on us for information.

Second, we must keep actively involved with the public throughout RD/RA. Many RPM's and CRC's are overworked, and cannot devote the time they would like to individual sites. But several things can be done to counter this limitation. We must be willing to meet the public, and not use overwork as an excuse to have as few meetings as possible. "I don't have anything new to tell them" is also unacceptable. Sometimes people just want to see a face and have someone who can answer questions. Being present often enough to be able to recognize people, and build alliances, can go a long way to successful community relations.

Third, existing local organizations can help build bridges in the community. These people have already done much groundwork that can be expanded on. They will appreciate it that you recognize their place in the community, as well.

Fourth, phone calls should be used to keep people informed. "We're here, we haven't forgotten you, we want you to feel comfortable calling us" are all important messages to send, over and over again.

Finally, do quality work and build on what you and others have done during RI/FS. Be prepared. Read notes and records so when you attend a meeting you can anticipate concerns, recognize names, and provide information that is relevant.

These are the "bells and whistles" that penetrate the noise of opposition. They aren't "smoke and mirrors," techniques to cover up and mislead. EPA has an obligation to investigate, study and clean up, but also, equally, to honestly inform and be available.

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Effects of Public Input and the Sampling Protocol on the Remedial Design Process

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INTRODUCTION

As the engineering world tackles the massive task of cleaning up our environment we find the work not only technologically challenging but also requiring local, state, and world acceptance. The trend of determining the most cost efficient remedy based only on technical factors without public support can no longer be the rule. This approach has run at least one superfund site ashore. The ship is moving ahead again largely due to the insistence that the program meet remedial action goals with a cost effective remedy that maintains the flexibility to meet residential homeowner needs as part of the design process.

As remedial actions increase in residential communities, the necessity of allowing flexibility in the design process cannot be stressed enough. Without the ability to meet individual homeowner needs, schedule and cost delays will be the rule not the exception. Even when utilizing remedies that have been proven over time and are minor in technical considerations and relatively accepted by the environmental and engineering communities, owner considerations must be included or the remedy may not be the most cost effective after schedule and cost delays are considered.

BACKGROUND

The Smuggler Mountain Site (site) is located in Aspen, Colorado. The old Smuggler Mine workings are located at the base of the western side of Smuggler Mountain. Waste rock and tailings from the mine cover much of the site. The mine wastes range from exposed, covered, or in many instances, mixed with native or imported soils. Much of the 110 acre site is developed. Some of the development is on top of the waste while in other cases waste piles have been moved and remain on the edges of the developments in the form of berms and mounds. The residential cleanup, operable unit # 1 (OU#1), consists of 2 large condominium complexes, 154 single family dwellings, numerous 4-12 unit apartment complexes, and a tennis club.

In the early 1980s soil analyses, first conducted by residents and later by the EPA and the potentially responsible parties (PRP), identified concentrations of lead up to 46,000 parts per million (ppm). Elevated levels of cadmium and other metals were also found. The potential for ground water contamination was also identified during the investigations. The site was proposed for the National Priorities List (NPL) in October 1984 and officially listed in May 1986.

In 1986, the EPA and the PRPs selected a remedy for soil cleanup in the residential area of the site. The remedy included creating an on-site repository to dispose of waste soils over 5,000 ppm lead. Waste soils with contamination concentrations between 1,000 and 5,000 ppm of lead were isolated by capping them with 6 to 12 inches of clean topsoil and then revegetating them. This also provided an alternative water source for residences who were utilizing ground water as their source of domestic water. During the design of the remedy, EPA conducted additional soil

sampling which indicated the contamination was highly variable in both the horizontal and vertical profiles. Based on this new data, EPA elected to review the proposed remedy. In March 1989, EPA drafted and presented to the community of Aspen an Explanation of Significant Differences (ESD). The main difference between the 1986 Record of Decision (ROD) and the 1989 ESD was that the depth of the clean fill cap was changed from 1 foot to 2 feet for areas between the 1,000 ppm and 5,000 ppm range. Additionally, the requirement for the repositories to have a cap permeability of 10-7 cm/sec was omitted as the soil sampling indicated the leaching of the hazardous materials was not a problem.

Public reaction to the ESD was generally negative. The need for any remedy was questioned. The risk assessment had not convinced the majority of the risk at the site.

Based on public reaction and the failure to gain public acceptance of the latest changes to the remedy, additional meetings between the EPA and the Pitkin County Commissioners were held. These discussions were the basis for yet another ESD in March 1990. The remedy was changed from a 2-feet soil cap back to a 1-foot cap with a geotextile barrier for much of the site and a 6-inch soil cap with stringent institutional controls for the two large condominium complexes. A requirement for additional soil sampling of each property was included in order to verify if and to the extent that contamination existed on that property.

The public comments to this ESD were similar to those in the previous ESD. The questions still indicated anger and frustration with the process. Many of the questions, however, were of a more personal nature. The people wanted to know what the remedy meant to them as a homeowner and what construction on their property would consist of.

DISCUSSION

The final ESD laid the ground work for building a firm base to approach the homeowners about the effects of the remedy on their property. This provided an opportunity to deal with actual homeowners and property issues rather than public outcry and general distrust. A main feature of the ESD was a commitment to complete soil sampling on each individual property. This commitment was the result of residents and local authorities requesting this procedure and EPA reviewing the newest (1988) soil sampling data which indicated that significant random distribution warranted the expense in order to save remedial action costs later. The public comments in this area centered on the actual sampling protocol. The sampling plan was finalized in June 1990.

The original approach to the sampling protocol was a statistical one which provided results that required remediation of the entire property or none of the property. After numerous discussions, the protocol agreed upon was a discrete sampling effort with individual results standing alone. This approach was consistent with all previous sampling programs at the site. Samples represented areas of specified size which determined which areas needed remedial action. The flexibility within the protocol allowed field crews to designate areas for sampling that qualified not only from a sampling approach but also from a design approach. The need to later remediate these areas was discussed with the location flagging members and, occasionally, design team members accompanied these teams to assure design needs were being met.

This sampling protocol provided the flexibility and forethought so that effective data could be directly incorporated into remedial action designs. Too often the efforts of site sampling are not well coordinated with the design parameters. In the latest sampling event at this site this problem was avoided by careful consideration of the design approach during development of the sampling plan and by effective follow through in the field.

Much of the publics' concern over the previous processes at this site was considered when developing the design philosophy. The following issues appeared to be the most important to overcome in the design phase:

(1) The public consistently indicated a mistrust in the representatives sent to discuss the remedy as previous representatives changed their decisions after consultations with the home office.

(2) Numerous times the public agreed that the things discussed at these meetings might work on their neighbors property but not on theirs.

(3) The public was no longer patient with excuses for schedule delays, and would likely not tolerate them in the future.

The design philosophy was established to provide the greatest opportunity to move this project into construction at the earliest possible date. The five underlying parameters of the philosophy were:

(1) Keep your tool box as full as possible.
(2) Maintain consistency without sacrificing flexibility.
(3) Cost efficiency is required but to save a dime on individual considerations that do not account for the increased costs overall will not be tolerated.
(4) Field designers must have the authority to agree to a remedy with the homeowner.
(5) The commitments made by the designers must be drawn for each lot with concurrence signatures by the homeowner, EPA, and the contracting agent (the Bureau of Reclamation).

To implement these parameters, a design criteria sheet was established for each physical item anticipated on the site. To assist in this effort a group of properties chosen randomly, were reviewed in detail with photographs and onsite review. The list of criteria was planned to be general enough so that the designers could know the criteria by memory. It was felt that owner reaction would be more favorable without the designer using a large volume of notes or guidance sheets during interviews. It was also felt that if the design criteria were too specific, the flexibility the program was striving for would be eliminated.

Based on this approach, 24 design criteria were developed.

The guidance sheets allowed for State and EPA approval. The public was also given an opportunity to understand the design issues prior to discussing them in the field. A typical design criteria sheet is shown in attachment 1.

Trees required special attention. Due to the publics' concern for remediation of their trees, special care was taken to assure that all reasonable options were considered. Seven options to remediate around trees were established.

The first design parameter was to keep the designer's tool box full. The tool box referred to the options or methods available to the designer in accomplishing their work. The parameter tried to avoid sending a plumber out to fix a leaky faucet with a hammer and nails, which sometimes happens when options are discarded too early in the process. This parameter allowed the designer maximum opportunities to successfully meet owner needs while maintaining the remedial requirements. With the criteria sheets providing at least three options for each issue, the tool box was full to meet the owner needs. This approach was foreign to many of the design

staff. Often the trend of the design engineers is to design a feature, complete the required drawings and specifications, and stand firm that this is the best way, and sometimes the only way to solve the problem. By eliminating this thought process and assuring that the professional engineering expertise was utilized to provide technically sound guidance to the owner in mixing and matching their available tools, technically sound protective remedies were developed that also were acceptable to the owner.

The second parameter was to maintain consistency without sacrificing flexibility. Again, the fact that each criteria sheet had a minimum number of three criteria provided this flexibility. The limitation to meet the issue with one of these three options assured relative consistency. Consistency was also established by having field engineers review each others work, thus providing a cross check and an assurance that the criteria sheets were being interpreted uniformly.

The third parameter seemed to be the most troubling to the people involved in the project. The legal staff pressed hard to assure that the absolute cheapest technical approach was completed. Though cost efficiency was indeed the objective of all participants, the consideration of cost effectiveness were not always the same. With a significant inflation rate to consider, it was imperative that decisions be made that would allow for the remedy to start and finish as soon as possible. Individual items of virtually no cost effectiveness were internally scrutinized. It became apparent that the path to cost efficiency lie in assuring a reasonable remedy that the public could accept at the earliest date was ultimately the most cost effective project. An example of this was the change in the criteria sheet for flowers. Originally, up to 20 perennial plants were being replaced. The public strongly disagreed with this approach, it was not an improvement, and left them with less than they had prior to remediation. To compensate for the change, the owners identified their plants and we would verify this during the preconstruction conference. By doing this we saved the cost of having a horticulturist identify the 20 plants and the increased cost of plants was minimal in most cases. This minor change may not make the difference between public opposition and support, but, the attitude displayed by the cooperation clearly provided a window of opportunity.

The fourth parameter allowed the field designers the authority to agree to a remedy with the homeowner. This parameter, more than any other, made the designers task possible. The homeowner's knowledge that the individual discussing their property could make onsite decisions without approval by someone else, clearly made a difference in executing the design interviews. The parameter is risky, but with selected staff it can produce a result that everyone can live with.

The fifth parameter provided an approved lot plan to the homeowner giving them that final level of trust. Not only did it leave them with a document verifying the agreements made during the interview, it also was one of the first times they received a hard copy commitment.

CONCLUSION

A design process can and should be formed to ensure that remedial goals are met, yet the process should be flexible enough to meet individual owner requirements. Without a commitment to model the sampling protocol around a remedial design approach and to meet homeowner needs in the design, the overall cost effectiveness will likely suffer.

DISCLAIMER

The above are the opinions and thoughts of the author and should not be considered EPA's, the Bureau of Reclamation's or the publics' position on these issues.

REFERENCES

U.S. Environmental Protection Agency. September 1986. Record of Decision, Smuggler Mountain, Pitkin County, Colorado

U.S. Environmental Protection Agency. March 1989 Soil Cleanup of Smuggler Mountain Site, Explanation of Significant Differences.

U.S. Environmental Protection Agency. March 1990 Draft, Soil Cleanup of Smuggler Mountain Site, Explanation of Significant Differences.

U.S. Environmental Protection Agency. July 6, 1990. Final Sampling and Analysis Plan for Smuggler Mountain, Aspen, Pitkin County, Colorado.

Field Design Criteria Sheet

Project: Smuggler Mountain Site

Issue Number: 3
Topic: Raised Patio, Decks, Walkways or Stairs
Date: March 8, 1990
Entry by: CBV

Structurally Sound is defined as an item that is functioning properly for its intended purpose and will not be harmed during the remedy.

Remedy Choices

A. Stay in place and excavate around if structurally sound, cost effective and:

1. There is no access to the contaminated material under the structure for people or animals, or
2. Access to the contaminated material under the structure is available only through a locked passageway, or
3. Contaminated material under the structure is isolated by a permanent cap, or
4. Skirting and a lockable access can be provided, or
5. A permanent cap can be provided under the structure such as 1 foot soil cap over a geotextile or concrete or asphalt.

B. Remove and replace with the same after remediating area below, if:

1. Cost effective, and
2. Approval of owner (alternative is to not replace, remove only)

C. Remove and replace with similar structure from approved choices if:

1. Cost effective, and
2. Approved by owner, or
3. Existing structure is not structurally sound design and can not be easily adjusted to such.

EPA Approval_____

Colorado State Approval_____

III. CONSTRUCTION MANAGEMENT ISSUES

REMEDIAL DESIGN AND REMEDIAL CONSTRUCTION AT THE PICILLO FARM SITE

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INTRODUCTION

This paper describes the successful remedial design and remedial construction efforts at the Picillo Farm Site in Rhode Island. The source control remedial measures performed at the site and described below illustrate how projects of this type can be appropriately managed and completed to the satisfaction of all participants.

In the Background section of this paper, the location and history of the Picillo Farm Site is presented. While the site received wastes for only a short time, it has special significance in the development of the Superfund program and still affects program decisions today. The Record of Decision (ROD) process and the project scope are also described.

A detailed Discussion section relates how the work was organized and performed. This section describes specific work practices that resulted in cost or schedule benefits and lists recommendations and suggestions for improving performance on similar projects.

BACKGROUND

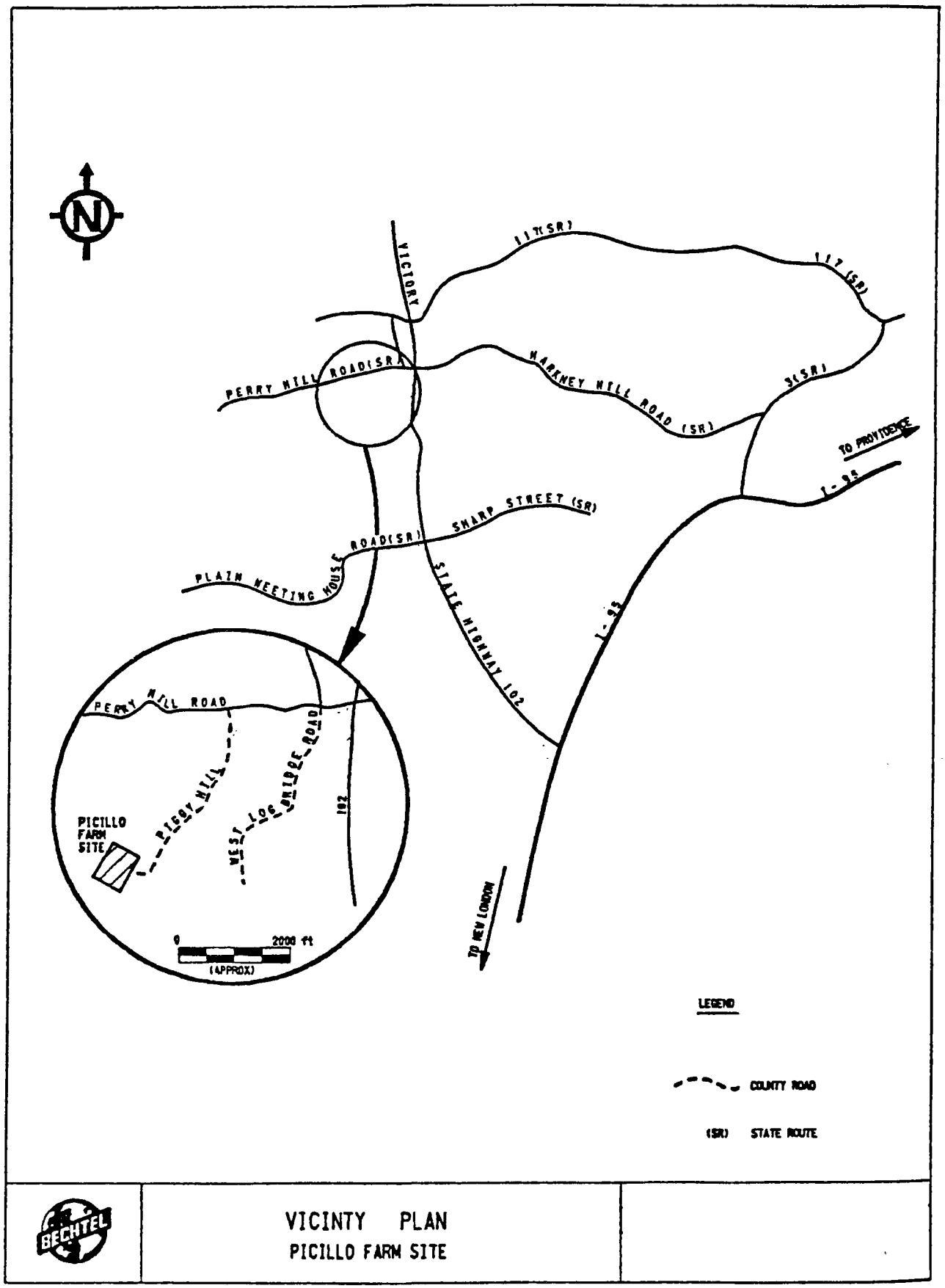
Site Location

The Picillo Farm Site is located in Coventry, Rhode Island, approximately 20 miles southwest of Providence and 1 mile southwest of the intersection of Route 102 and Perry Hill Road (Figure 1).

The area used for disposal consists of approximately 8 acres of cleared land that is surrounded by woodlands and wetlands and that slopes to the northwest toward a swamp (Figure 2). This site was listed on the first National Priorities List (NPL) published in September 1983.

Site History

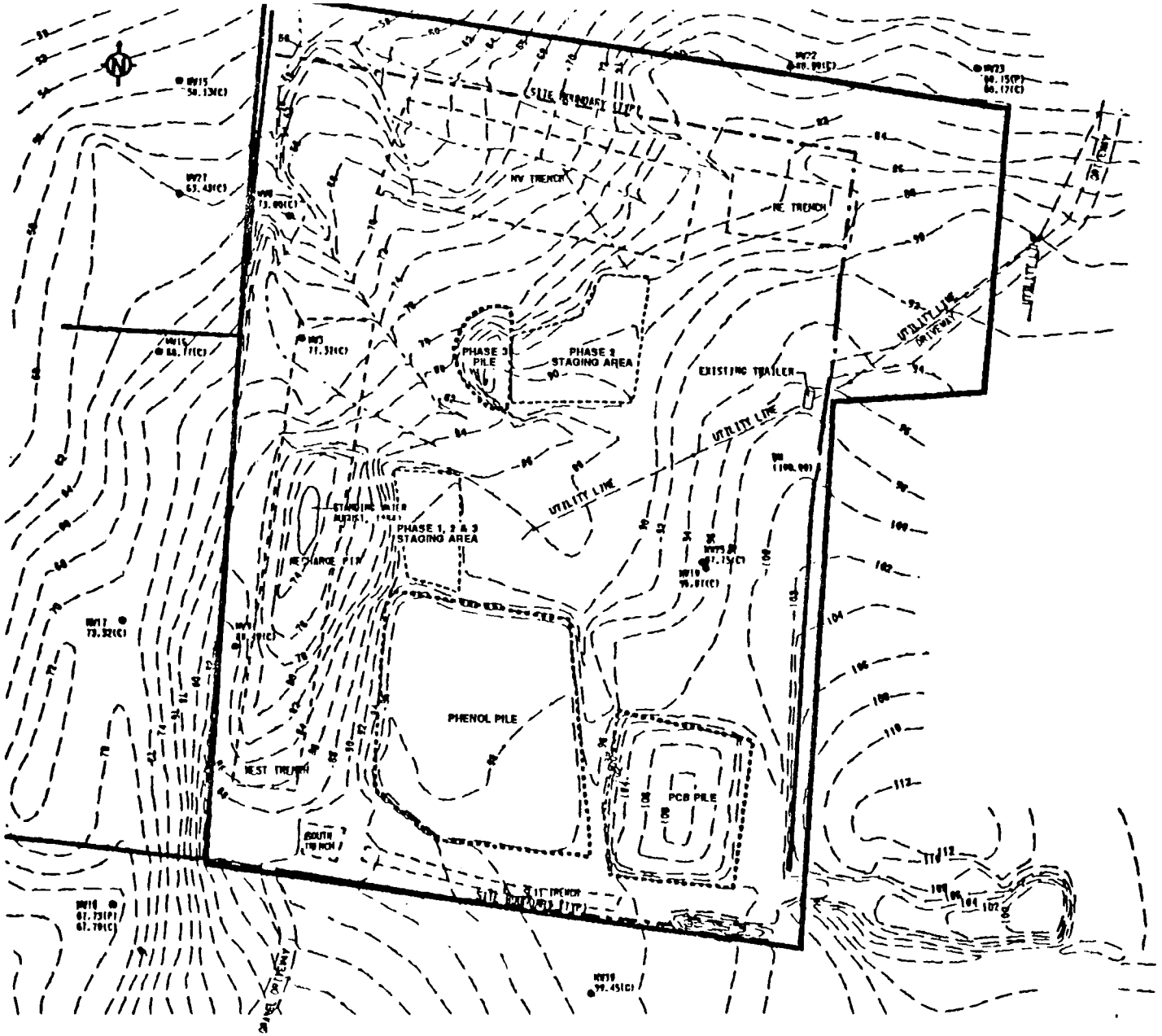
Over a period of months in 1977, drums of hazardous wastes and bulk materials were illegally disposed at the site. A series of trenches were excavated at various locations and used for disposal. An explosion and fire in September 1977 attracted the attention of regulators to the disposal activities.



BECHTEL

VICINTY PLAN
PICILLO FARM SITE

Figure 1



PICILLO SITE PLAN

Figure 2

Since the discovery of the dumping activities, a number of investigations and remedial activities have been conducted. The Rhode Island Department of Environmental Management (RIDEM) and the Environmental Protection Agency (EPA) have been jointly involved in these efforts.

In September 1980, the Northeast Trench was excavated by a RIDEM contractor, and 2,314 drums were removed. Soils from this trench were contaminated with PCBs and other organic contaminants and were stockpiled in the southeast corner of the site. This material is referred to as the PCB Pile.

Another RIDEM contractor began excavation of drums from the Northwest Trench in March 1981 and concluded in June after 4,500 containers and the contaminated soils had been removed. Those soils and drums were disposed offsite.

In May 1982, RIDEM contractors began excavation of the West Trench, South Trench, and two slit trenches. During this effort, 3,300 drums were removed and disposed offsite. The contaminated soil from the excavation contained elevated concentrations of phenol and was placed into two piles near the center of the site (Phenol Pile and Phase 3 Pile). This action completed the removal of buried drums that had been identified by previous studies. Exploratory excavations were conducted around the site and no additional drums were discovered.

Table 1 shows the 1985 estimate of the soil pile volumes and average contaminant concentrations.

Table 1

	Volume*	Average Contaminant Concentration (1985)
PCB Pile	3,500 cy	36.8 ppm (180 ppm max.)
Phenol Pile	2,000 cy	70 ppm
Phase 3 Pile	1,000 cy	3,000 ppm

* 1985 Estimate

A RIDEM contractor began landfarming the Phenol Pile in September 1982 and continued for several months. Phenol concentrations in this soil decreased from approximately 870 ppm to about 70 ppm. Pilot studies conducted to determine the biodegradability of contaminants in the PCB Pile showed that landfarming would not produce satisfactory results on that material.

Following completion of additional studies and a public comment period, the initial ROD was signed September 30, 1985. The selected remedy addressed source control and involved the onsite disposal of contaminated soils in a RCRA/TSCA landfill. Groundwater remedial action was not specifically addressed. A remedy for this issue was to be selected in a later ROD.

After the initial ROD was issued, the state of Rhode Island filed suit to prevent implementation of the selected remedy. The basis for this suit was a state law that prohibited the land disposal of "extremely hazardous waste" as defined in the state statute. This state law directly applied to the PCB Pile materials. At the time, EPA's position was that Superfund remedy decisions were legally exempt from State and local laws. However, the Superfund Amendments and Reauthorization Act of 1986 (SARA) required EPA to conform the selected remedy to the State's standard prohibiting the land disposal of "extremely hazardous wastes." As a result, a second ROD was issued March 3, 1987 that specified the offsite disposal of contaminated soils and the implementation of other site closure and operations and maintenance (O & M) activities. This is the source control ROD that was ultimately implemented at the site.

Project Scope

In August 1987, four major chemical companies entered into a Consent Decree and agreed to perform the following:

- Dispose of the PCB Pile, Phenol Pile and Phase 3 Pile, accumulated samples, empty drums, and miscellaneous debris at an offsite location
- Install a perimeter fence
- Install a run-on control and runoff management system including filling, grading, and vegetating the site for erosion control
- Maintain the site for one year

Bechtel under contract to these firms, provided design engineering, project management, onsite construction management, and health and safety services during the project.

Prior to field implementation of the remedy, a work plan covering remedial design and remedial action was developed and negotiated

with EPA and RIDEM. Bechtel then proceeded with developing the remedial design and solicitation of bids for the remedial action.

Following EPA and RIDEM approval of design documents remedial action commenced.

DISCUSSION

Project Schedule

The schedule was a major factor influencing the sequence and timing of project operations. The project schedule as implemented is shown in Figure 3.

The schedule for the project was complicated by the length of the construction season and provisions of the Consent Decree. The relatively short construction season required earthwork and seeding to be completed by early-to-mid-October to avoid freezing weather and conditions adverse to plant growth. The other complicating factor was a provision in the Consent Decree that required the removal of all hazardous materials from the site within 120 days of work plan approval. Another provision required all work (except seeding) to be performed within 90 days of waste removal; penalties were to be assessed for each day of noncompliance.

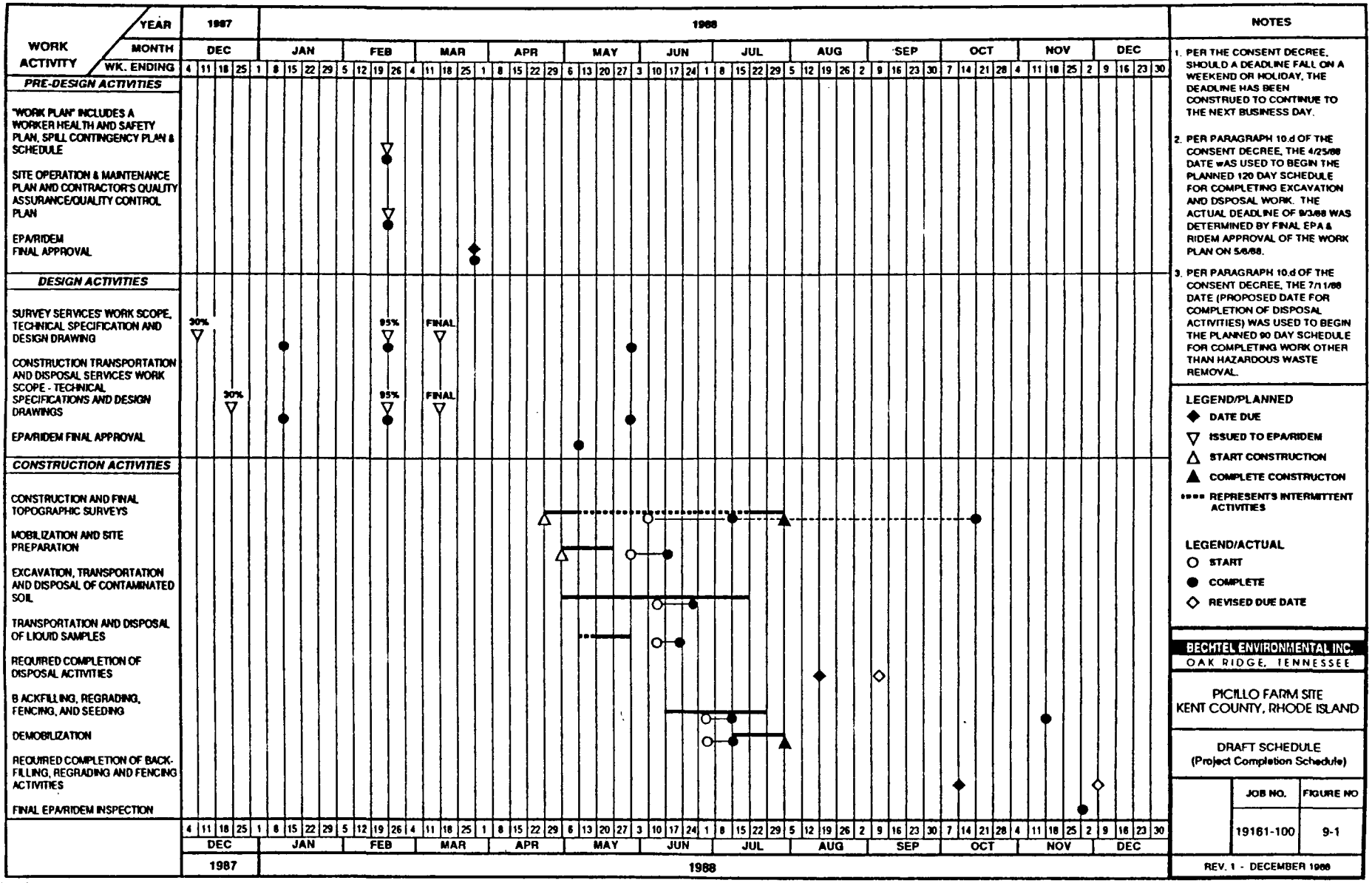
As Figure 3 shows, all Consent Decree milestones were met and the work was completed significantly ahead of schedule. Consent Decree milestones are shown as planned events on Figure 3.

Work Plan

Immediately following the Consent Order effective date, Bechtel began preparing the work plan. This document addressed all aspects of the project and was prepared in accordance with the EPA document "Remedial Design and Remedial Action Guidance."

The work plan consisted of the following:

- Introduction and Purpose
- Design Engineering
- Permits



NOTES

1. PER THE CONSENT DECREE, SHOULD A DEADLINE FALL ON A WEEKEND OR HOLIDAY, THE DEADLINE HAS BEEN CONSTRUED TO CONTINUE TO THE NEXT BUSINESS DAY.
2. PER PARAGRAPH 10.d OF THE CONSENT DECREE, THE 4/25/88 DATE WAS USED TO BEGIN THE PLANNED 120 DAY SCHEDULE FOR COMPLETING EXCAVATION AND DSPOSAL WORK. THE ACTUAL DEADLINE OF 9/3/88 WAS DETERMINED BY FINAL EPA & RIDEM APPROVAL OF THE WORK PLAN ON 5/6/88.
3. PER PARAGRAPH 10.d OF THE CONSENT DECREE, THE 7/11/88 DATE (PROPOSED DATE FOR COMPLETION OF DISPOSAL ACTIVITIES) WAS USED TO BEGIN THE PLANNED 90 DAY SCHEDULE FOR COMPLETING WORK OTHER THAN HAZARDOUS WASTE REMOVAL.

LEGEND/PLANNED

- ◆ DATE DUE
- ▽ ISSUED TO EPA/RIDEM
- △ START CONSTRUCTION
- ▲ COMPLETE CONSTRUCTON
- •••• REPRESENTS INTERMITTENT ACTIVITIES

LEGEND/ACTUAL

- ○ START
- ● COMPLETE
- ◇ REVISED DUE DATE

BECHTEL ENVIRONMENTAL INC.
OAK RIDGE, TENNESSEE

PICILLO FARM SITE
KENT COUNTY, RHODE ISLAND

DRAFT SCHEDULE
(Project Completion Schedule)

JOB NO.	FIGURE NO
19161-100	9-1

REV. 1 - DECEMBER 1988

1 5 0228.3

Figure 3

- Remedial Action
  - Site Preparation
  - Land Surveying
  - Disposal of Contaminated Materials
  - Site Closure
  - Construction Monitoring and Inspection
  - Disposal Facilities
  - Post Closure Plan
  - Health and Safety Plan
  - Contingency Plan
  - Schedule
  - Work Not Included
  - References
  - Design Drawings (preliminary)

The work plan formed the basis for the remaining activities at the site and received final approval (with comments) in March 1988.

Remedial Design

To expedite the schedule and allow remedial action to be conducted during the 1988 construction season, design work proceeded in parallel with work plan preparation. The design was submitted to EPA and RIDEM for review and comment at the 30% and 95% stages and for final approval at the 100% stage. EPA, RIDEM, and Bechtel agreed that a review at the 60% stage would not be necessary, and this milestone was eliminated from the schedule. Concurrent with the remedial design, solicitation packages for the remedial action were prepared. These documents were issued to prospective bidders when the design was undergoing EPA/RIDEM review at the 95% stage. Once final agency approval was obtained, contractors were selected and contracts finalized. Contractors mobilized onsite the week following design approval.

Of particular interest during the design phase was the procedure used for selecting the final disposal sites. Under the terms of the Consent Decree, the Potentially Responsible Parties (PRPs) were to attempt to locate disposal sites for the wastes. If the PRPs were unsuccessful, the Consent Decree (and SARA) required the State of Rhode Island to identify and make a disposal site available.

As part of this process, firms bidding on the remedial work were required to present a primary and secondary disposal site for review and approval. This list of primary and secondary sites was compiled and submitted to EPA for review. EPA reviewed each facility on the list for compliance with the "offsite policy" and found none to be in compliance. Alternate disposal sites were then identified, with the assistance of EPA, and amended quotations were requested from the bidders. Contract award was based on the amended quotations.

After this selection process, EPA approved the following sites for disposal of materials from the Picillo Farm Site.

PCB Waste	Chemical Waste Management, Emelle, Alabama
Phenol Waste	Chemical Waste Management, Fort Wayne, Indiana Chemical Waste Management, Emelle, Alabama
Liquid PCB Waste	Chemical Waste Management, Chicago, Illinois

Remedial Action

Implementation of the source control remedy began in May 1988 with the mobilization of construction forces to the field. Bechtel personnel made initial contacts with local officials and explained project operations to local emergency services representatives. Community officials were brought to the site prior to excavation activities to familiarize them with the site, access routes, project personnel, and objectives.

Personnel working at the site were required to comply with the approved Health and Safety Plan, which included a medical surveillance program and detailed requirements for training and the use of personal protective clothing. These measures remained in effect until waste had been removed from the site and areas were released for backfill/grading operations.

During excavation operations, haul trucks were preweighed at portable scales erected and calibrated at the site and then loaded on an uncontaminated haul road constructed adjacent to all three waste piles. A backhoe stationed on top of the waste pile being excavated was used to load the trucks. A bulldozer pushed material to the backhoe to facilitate loading and minimize the loading cycle time. Once a truck was loaded, it proceeded to the decontamination area; there a tarpaulin was installed over the bed and the truck was washed. After this decontamination, trucks proceeded to the scales where they were weighed and inspected. Manifests were completed prior to leaving the site. Waste loads were tracked and completed manifests were compiled to verify proper disposal of the wastes.

Water generated during decontamination and other onsite operations was collected and used to moisture-condition the soils prior to excavation and transport. As a result, all water generated during the work was utilized and none required treatment or offsite disposal.

Excavation of the PCB Pile began in June 1988 and continued for approximately one week. During this time, 6,212 tons (3,800 cubic yards) or 281 truckloads, of soil and debris were removed. Average production was 43 truckloads or 956 tons per day. Virtually all

excavation work was conducted in Level C personal protective equipment.

The Phenol Pile was removed over a two-week period. In the excavation of this material, production was limited by the receiving capacity of the disposal facility. In all, 6,426 tons (4,100 cubic yards) or 284 truckloads of material were removed and transported. Average production was 31.5 truckloads or 714 tons per day. Similarly, the Phase 3 Pile was excavated over a four-day period, with 1,073 tons (700 cubic yards) or 45 truckloads removed and transported. Daily production on the Phase 3 Pile averaged 11 truckloads or 268 tons.

Concurrent with the soil removal operation, waste samples stored in an onsite trailer were examined, tested, combined and shipped offsite for disposal. In all, 5,111 sample jars were handled, the majority of which contained solid materials that could be disposed with the soil and debris. After compatibility testing, approximately 30 gallons of PCB-contaminated flammable liquids remained. These liquids were disposed offsite by incineration.

During the latter stages of Phase 3 Pile excavation, EPA approved the use of an adjacent borrow area as a source of material for backfilling the West Trench area. This backfill operation began as the Phase 3 Pile excavation was concluding and continued for seven working days. A total of 5,200 cubic yards (717 truckloads) of backfill were placed; average daily production was 743 cubic yards or 102 truckloads. Other areas of the site were regraded to promote runoff. The areas formerly occupied by the waste piles did not require regrading or backfilling, because these areas were excavated such that their drainage characteristics were similar to the surrounding terrain.

Initial reseeding of the site was performed in mid-October 1988. The entire area within the perimeter fence, and selected areas outside the fence, were sown with a grass seed mixture formulated to provide adequate cover and erosion resistance while requiring little maintenance.

The final EPA/RIDEM inspection of remedial construction activities was conducted November 28, 1988. All construction activities were approved and final EPA/RIDEM acceptance was obtained on January 4, 1989.

The O & M period began after acceptance of the construction work and continued for one year. During the O & M phase of the work, periodic inspections were conducted with EPA and RIDEM personnel, minor regrading and erosion repair was completed; and selected areas of the site were reseeded. The O & M period ended in January 1990 with EPA and RIDEM approval of all activities. EPA and RIDEM also concurred that the terms of the Consent Decree had been

satisfied and released the PRPs from further obligations under that agreement.

Current Site Status

At the end of the O & M period, the site was in a stable condition with a well established cover of vegetation. The areas formerly occupied by the Phenol Pile and Phase 3 Pile exhibited little residual contamination. However, while contamination levels in the PCB Pile area are below the Federal standard of 50 ppm, the levels are above the state standard of 1 ppm. Any future remedial action on this material will be performed by the state.

Groundwater contamination still remains at the site. The source control remedial actions described above were not intended to directly contribute to cleanup of the existing groundwater contamination, and this issue is still under investigation by EPA and RIDEM.

RECOMMENDATIONS

As a result of work at the Picillo Farm site, the following recommendations are made.

- Where possible, define operable units or work packages so that fixed unit price contracts can be used, enabling improved cost/schedule performance

- Where possible, negotiate Consent Decree terms to fix the scope (in this case, excavation of piles to existing grade) and avoid contamination chasing

- Encourage EPA and state agencies to commit to review times in the Consent Decree

- Negotiate an agreement with EPA and the state agency that either agency's onsite representative may act for the other when absent

- Develop a working relationship with EPA and the state agency to facilitate understanding of project goals and operations

- Involve the EPA Offsite Policy Coordinator in disposal site selection from an early date to avoid last minute changes in disposal site status

- Coordinate site activities with local officials and emergency service personnel and enlist their help in community relations

- Ensure project objectives are adequately defined for all onsite personnel
- Prepare a community relations plan and indoctrinate all onsite personnel in dealing with media and visitors

REFERENCES

U.S. Environmental Protection Agency, Record of Decision, Picillo Farm Site, Coventry, Rhode Island; September 30, 1985.

U.S. Environmental Protection Agency, Amended Record of Decision, Picillo Farm Site, Coventry, Rhode Island; March 3, 1987.

Bechtel Environmental, Inc., Final Report for the Picillo Farm Superfund Site Remediation Activities, Oak Ridge, Tennessee; January 1989.

Remedial and Post-Construction Activities at the Triangle Chemical Company Site

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INTRODUCTION

The conditions found at Triangle Chemical Company, which was a typical small chemical company, may represent the picture of thousands of other similar companies around the country. This will only become evident when they cease to operate or are forced to investigate "normal, minor" spills.

BACKGROUND

Triangle Chemical Company is a bankrupt, abandoned chemical blending and packaging company. It is located on Coon Bayou which is a tributary of Cow Bayou in Bridge City, Texas. Figure 1 and 2 show the proximity and location of the site. EPA took control of this superfund site in 1982 after a follow up visit of a fish kill investigation. The officials found the site deserted and subsequently conducted an immediate response action. They removed approximately 1,000 drums containing 21,000 gallons of liquid waste which were stored on the ground in the open with no containment. Figure 3 shows the condition of the site at the time.

Contamination remaining at the site was generally volatile organic compounds in the soil and upper aquifer. In addition there were several large tanks with another 50,000 gallons of various chemicals. These were emptied and cleaned during the Remedial Action(RA).

The soil below the surface layer is generally clay, with occasional sandy lenses, which are not interconnected. The clay continues to about thirty five feet below the surface. There are some shallow (less than 75 foot) wells in the area, but all known domestic water wells are in the deeper aquifer at a depth of three hundred to four hundred feet.

The Site Remedial Investigation(RI) and subsequent Feasibility Study(FS), Remedial Design(RD), administration of the Remedial Action(RA) and Operation and Maintenance(O&M) were all performed by the Houston office of Roy F. Weston, Inc, West Chester, Pa.(WESTON) under a contract issued by Texas Water Commission(TWC). This is a state lead Federal Superfund site. The RA contractor was Ensco Environmental Services, Port Allen La.(ENSCO)

REMEDIAL ACTION

Following a detailed RI/FS by WESTON, mechanical aeration of the soil and natural attenuation of groundwater were chosen as the selected treatment methods. Mechanical aeration (soil tilling) was tested to verify the effectiveness, utilizing a full scale pilot study during the RD phase. The results of this pilot study were also used to form the basis for development of field controls for the remediation. The remediation was conducted by ENSCO on a compressed, 5 week, schedule, and was completed in February, 1987.

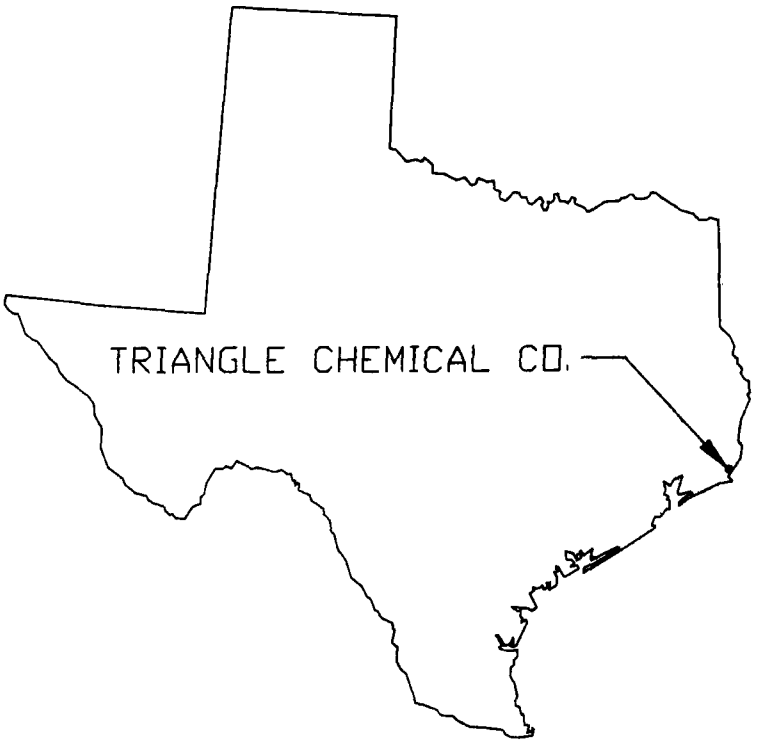

Figure 1 Site Location Map

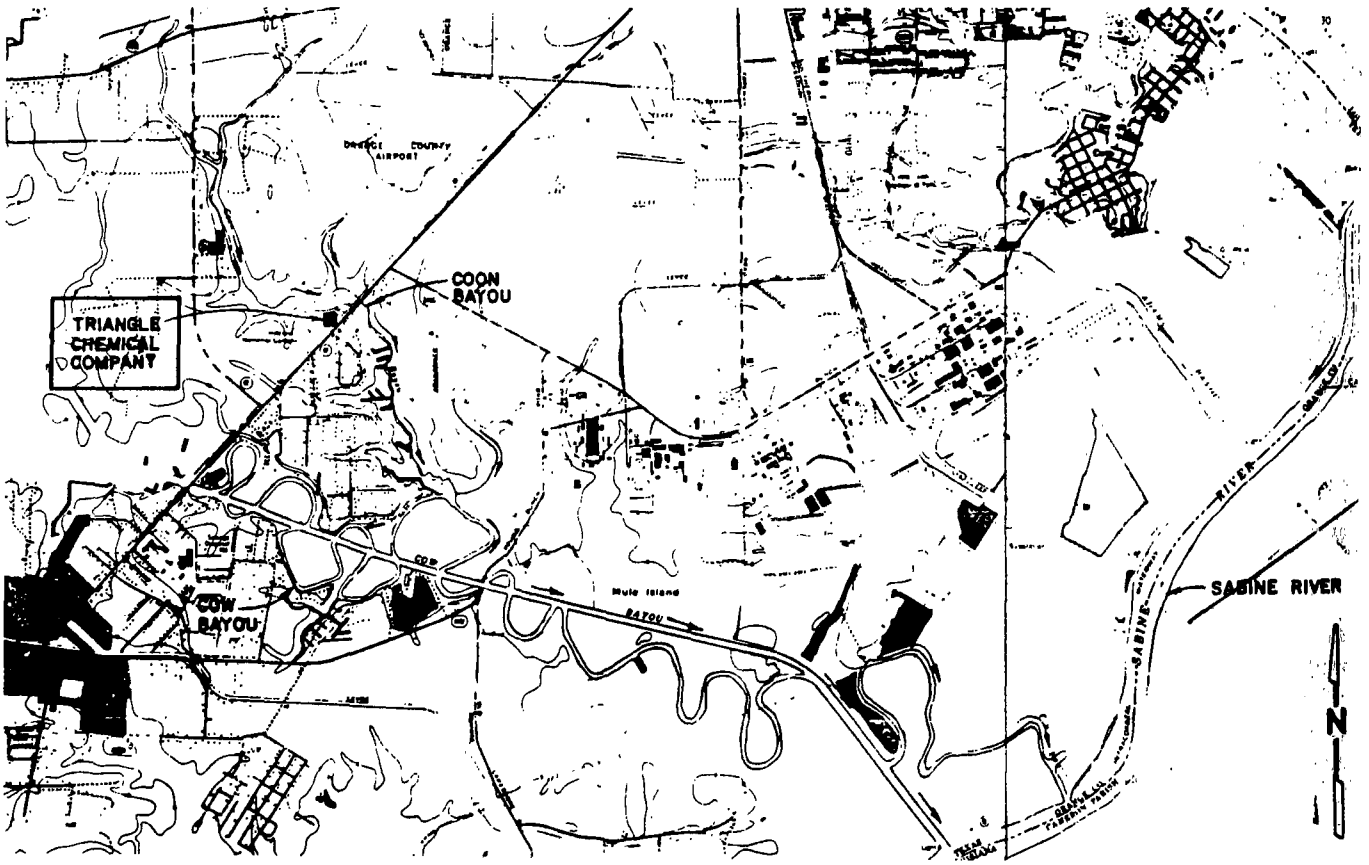

Figure 2 Vicinity Map (from USGS Quad Orangefield TX-LA)

Figure 3 1982 Aerial Photo before Immediate Response Action

SOIL REMEDIATION

There were three areas identified on the site in which the upper four to six feet of soil were contaminated with volatile organic compounds. This depth corresponds to approximately mean sea level in each case with the groundwater level about one to three feet below the surface. These contaminated areas are shown on figure 4 and are identified as till areas A, B, & C, inside the bold outlines and can be seen in figure 5, also surrounded by hay bales. The soil in each of the areas is generally sandy or silty for the first two feet and a heavy clay with occasional small sand lenses from two feet to about thirty-five feet below the surface.

The Specifications called for the soil in each area to be tilled in layers up to eight inch thick until the level of volatile organics in each layer tested below 5 ppm using a field jar test described later. Each layer was to be tilled, tested and removed to a stockpile the same day so that loose soil would not be left spread out and exposed over night. In addition, each of the active till areas were to be covered at night to protect them from rain. This was to continue until no more contamination was detected or until groundwater prevented them from continuing. After off site laboratory verification was completed, the contractor would be allowed to use the decontaminated soil to backfill the excavations.

Early in the remediation, due to the limited space, ENSCO chose to use a large garden tiller, partially shown in figure 6, but soon found out that a heavier machine was needed. The sandy soil broke up easily with the small tiller, and only required a few hours of work before the six inch tilled layer was ready to move to the stockpile and start on the next layer. The six inch layers were actually only about four inches in place, so progress was slow. The highway mixer, shown in figure 7, was brought in when progress was at about sixteen inches deep level, and progress improved considerably. The mixer could cut to a depth of up to twenty four inches at one pass, but in order to break up the soil into the smallest particles possible and expose them to the air, only twelve inch maximum layers were used. At this thickness the tilled layer could still be completed and removed in one day. The mixer made approximately four passes over each layer to fully pulverize it, then allowed it to volatilize for an hour or so before reworking the same area. After working the soil the second time it usually passed the test and was stockpiled. This process continued well below the groundwater level and in the final layers the moisture content increased as it was tilled. Despite the moisture, the equipment had very little trouble and the volatilization continues to approximately sea level. Tilling was slow in the high moisture, heavy clay, and at times the tiller actually had to shave off small pieces to keep it from balling up inside the machine. Tilling was stopped when groundwater accumulation in the bottom of the excavation hindered the progress.

VERIFICATION TESTING

The verification test consisted of a series of tests conducted using a Foxboro 128 organic vapor analyzer (OVA). The first test was done in place in the freshly tilled soil. The probe of the OVA was carefully inserted about two inches into a fresh one inch diameter hole which extended to the bottom of the tilled soil. This test indicated up to over 1000 ppm when the soil was first disturbed, but quickly dropped after the soil was broken up. When no indication of contamination was found in the in-situ test, a soil sample was collected for a field jar test. Each quart sample jar was filled approximately half full with the loose soil from the areas that last yielded a reading. At least three samples were taken from each layer. These were sealed with a layer of aluminum foil under the lids and placed in boiling water for five minutes. This raised the temperature of the soil to 180° F. After five minutes the jar was removed from the boiling water and was briefly shaken. The lid was removed, and a small hole was created in the aluminum foil which was still in place on the jar. The OVA probe was inserted into the small hole in the aluminum foil. If the reading was less than 5 ppm on all tests for a layer then that layer was considered clean enough to be stockpiled and eventually placed back in the excavation as backfill. Duplicate samples were analyzed for volatile organic

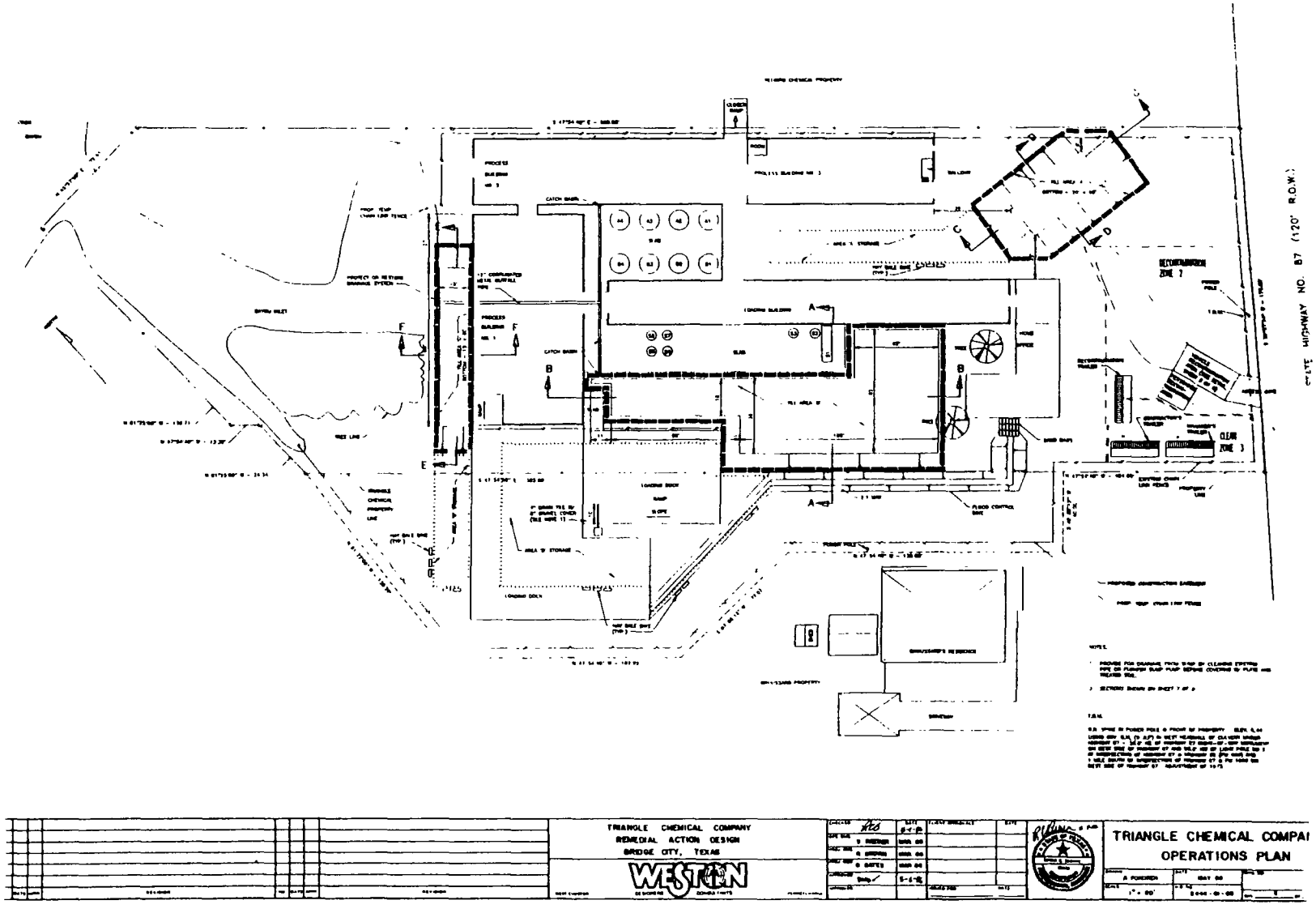

Figure 4 Operation Plan from RA Bid Documents

Figure 5 Aerial Photo During Remedial Action

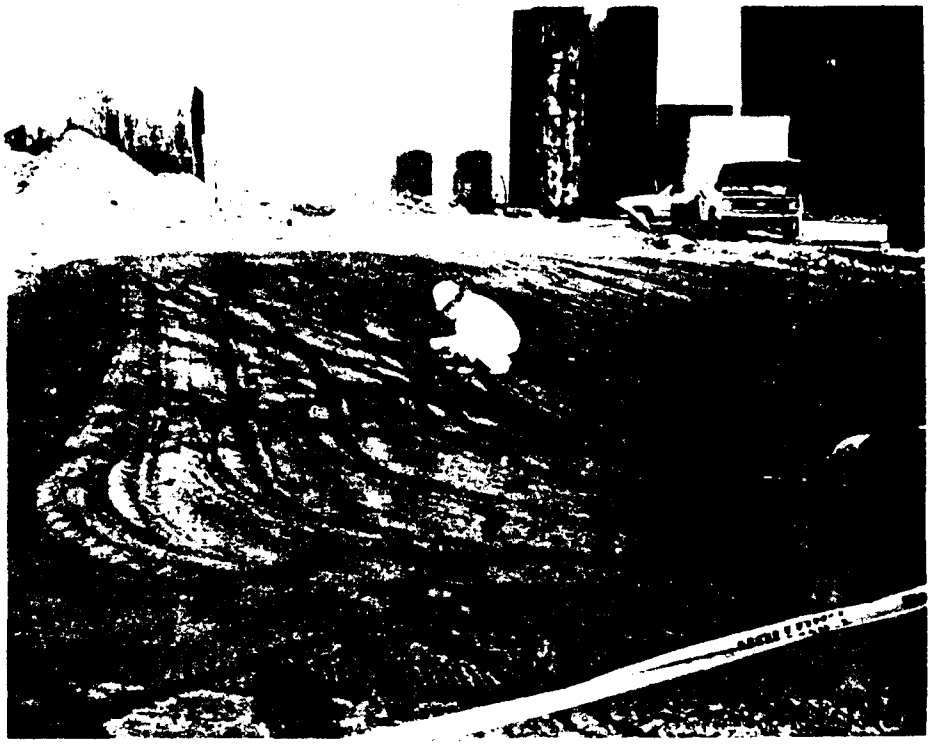

Figure 6 Collecting Sample Behind Garden Tractor w/Small Tiller

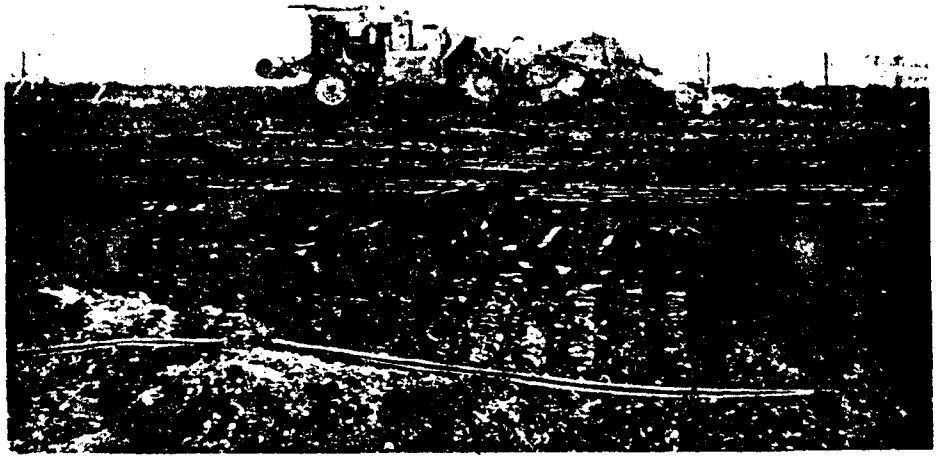

Figure 7 Large Highway Mixer

priority pollutants using GCMS technology which were used to verify that the soil had been cleaned up. The GCMS analysis in an off site laboratory test took several days, and were not used as a control, but only to verify the results of the non-standard field test.

The air emissions during the soil tilling was very low. The work was all done in level "C" protection, even though the levels of contamination in the air were seldom detectable in the breathing zone except immediately behind the tiller.

The Triangle property is actually two properties separated by the Red Bird Chemical Co., which is no longer in business. Compare the 1982 aerial photo in figure 3 with the property lines shown in figure 4. Red Bird Chemical Co.'s activities and products were very similar to Triangle's, which lead the Immediate Action Team to miss over 100 drums that were on the northerly piece of property, beyond the Red Bird Property. These drums were in and around the shed in the upper center of figure 3, and were removed and disposed of as part of the RA contract by ENSCO.

BUILDING & TANK DECONTAMINATION

Building decontamination was preceded by identifying, sorting, loading and disposal of the piles of abandoned material, which had been scattered throughout the buildings. The carpeting in the offices were removed because of several large stains from lab chemicals which had been spilled. All the materials that were visually identified as possibly contaminated were sent to a class 1 hazardous landfill, and the obviously uncontaminated materials were disposed of in a local class 1 non-hazardous landfill. The building floors, including the office and lab area, were washed with hot detergent and sealed. There was only one area in the mixing building that had chemicals splashed on the walls. This area was cleaned similar to the tanks. The 23 tanks on site were cleaned using hot detergent, and triple hot water rinse.

GROUNDWATER CONTAMINATION

The original RI, performed in early 1984 at this site, demonstrates one of the problems associated with every soils investigation. Analysis performed on a discrete soil sample, from specific depth and locations, may not be representative of what may exist in another area close to the first that was not sampled. Samples were collected, and penetrations were made to depths of at least twenty feet in all accessible areas over the entire site on a typical grid pattern. The major soil contamination on site was found in the top six feet of soil, and only slight contamination was found in the groundwater deeper than that. At this time, one monitoring well was placed upgradient of the soil contamination, and two were placed downgradient. No measurable contamination was detected in any of these three original wells. The remediation method chosen included removing and replacing the upgradient well, M W #2, because it was in an area which was to be tilled. The replacement well, M W #4, was placed in a central downgradient from the soil contamination location in order to monitor potential contamination in the area. It was installed by ENSCO as close to the building as possible in order to be out of danger from future occupants traffic. Total priority pollutants of over 25000 ppm were detected in the groundwater sample collected from this well. Methylene Chloride, which had not been previously found on site, was one of the major contaminant detected in this well. Because of this, and other questions concerning the construction of this well, two additional monitoring wells were installed in the area. One, M W #5, was placed about fifteen feet east of M W #4, and the other one, M W #6 was placed west of M W #4, in another downgradient location where part of a building had been removed by ENSCO during the RA. Both M W #6 and M W #5 confirmed that there was indeed significant contamination in the groundwater. A supplemental groundwater investigation was performed which confirmed that this was a small plume of contamination in the shallow groundwater. During this investigation monitoring wells were installed, and cone penetrometers were used on the downgradient property, inside the buildings, and in a grid pattern adjacent to the plume. One 80 foot

deep well, M W #7, which extends to the second waterbearing zone was installed adjacent to M W #6. Two of the new wells in the area of M W #5, M W #10 and M W #11, show some contamination, but not to the same degree as M W #5 & #6. Neither the new deep well, nor the 400 foot wells on the neighboring properties to the north and south, revealed any detectable priority pollutants when sampled and analyzed. Pump tests and modeling of the shallow and deep groundwater movement was conducted and natural attenuation was again confirmed as the selected method of remediation.

DATA EVALUATION AND CONCLUSIONS

Data from quarterly O&M groundwater samples collected since 1987 has produced a data base which has been used to project the natural attenuation rates expected. Out of the more than twenty volatile organic compounds which were found on site, six compounds were selected as indicators of the level of contamination on site. These six compounds, Vinyl Chloride (VC), Methylene Chloride (MC), 1,1-Dichloroethene (1,1-DCEE), 1,1-Dichloroethane (1,1-DCEA), 1,2-Dichloroethene (1,2-DCEE), and Trichloroethene (TCE) are used to determine if improvement or deterioration of the groundwater is taking place. Figure #8 and #9 are graphs of the levels of each of these in the monitor wells M W #5 and M W #6, respectively.

Reduction of concentration of chemicals in the groundwater at a specific location is the result of many simultaneous attenuation processes. These include migration downgradient with the groundwater, dispersion, dilution by recharging sources, as well as natural attenuation by degradation, evaporation or volatilization. The attenuation rate itself is dependent on the characteristics of each chemical, as well as the saturation level of each chemical, in the particular combination with the other chemicals present.

OBSERVATIONS AND CONCLUSIONS

The attenuation rate was projected using the first order decay [$Y=Y_o(e^{-kt})$] of each compound based on the data collected to date. Figures #10 and #11 presents a sum of the projected levels of all six of the target compounds for each of the two heaviest contaminated wells, M W #5 and M W #6. This was done for each contaminant separately by taking the natural log of each contaminant level and projecting them to a level of 1 ppm. The projected logs are then converted to contaminant levels before being combined with others from that monitoring well to be graphed. The projections are based on the samples which have been collected on a quarterly bases since these two monitoring wells were installed in April 1988. The projected attenuation has not changed significantly with each year's added data. This seems to indicate that the use of the first order decay was a reasonable method for projecting natural attenuation at this site. This may be applicable to similar other sites which no longer have a contaminant source.

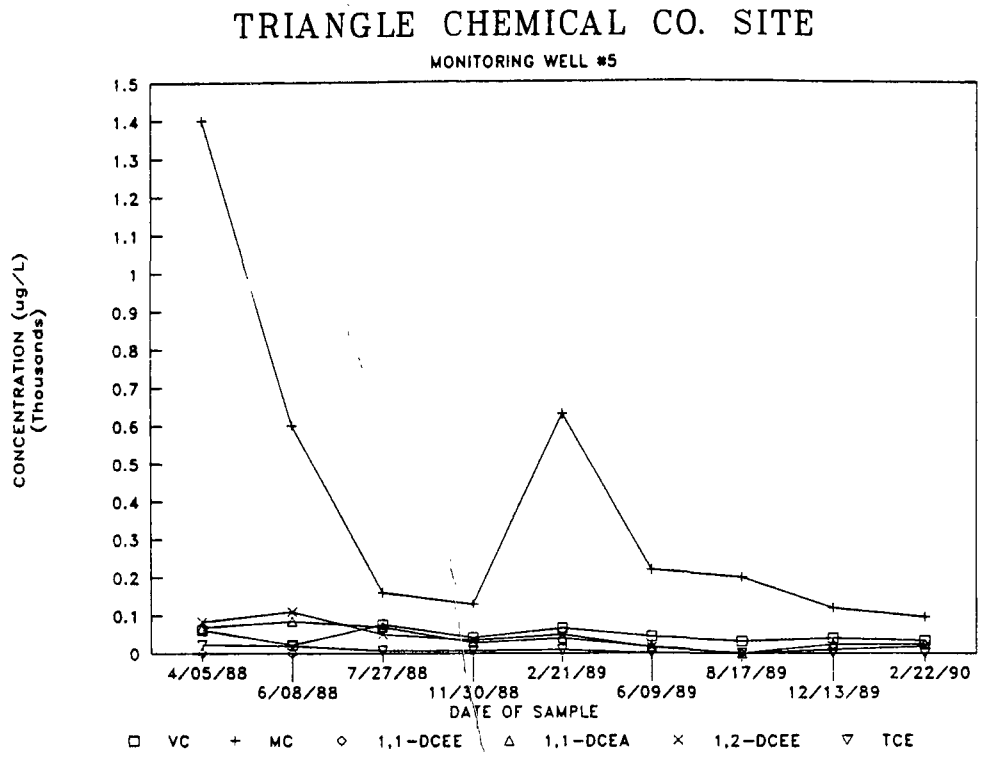

Figure 8 **Monitoring Well #5 Contaminant Level By Contaminant**

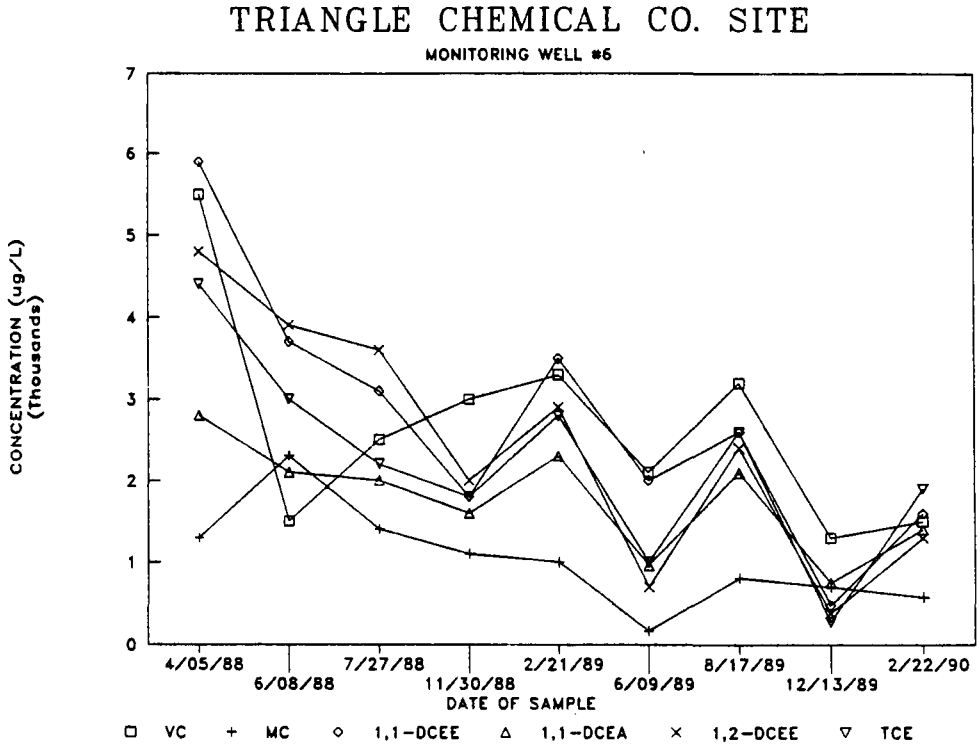

Figure 9 **Monitoring Well #6 Contaminant Level By Contaminant**

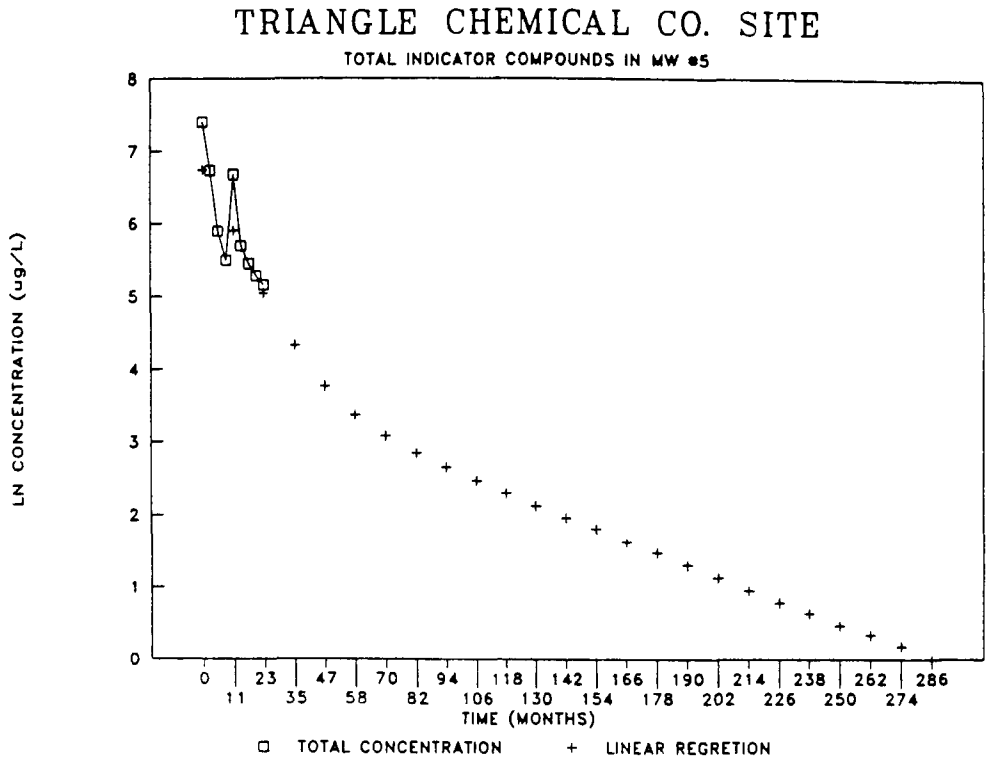

Figure 10 Monitoring Well #5 Contaminant Reduction Projections

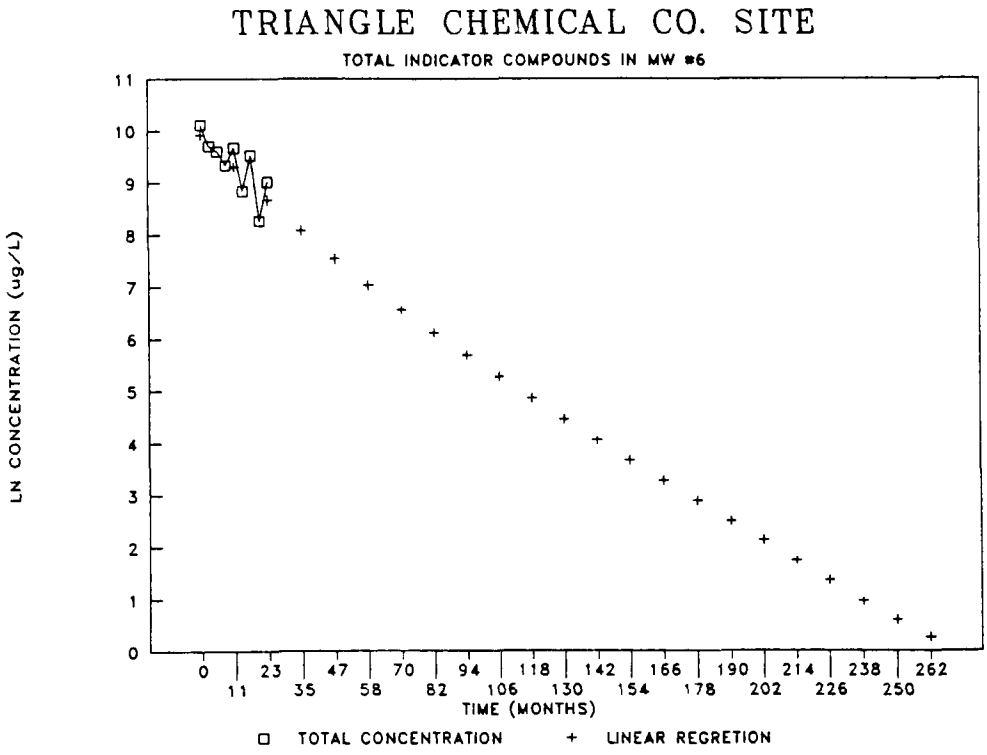

Figure 11 Monitoring Well #6 Contaminant Reduction Projections

CONCRETE COVER APPLICATIONS IN LINED DRAINAGE DITCH CONSTRUCTION

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INTRODUCTION

This paper presents details on the application of concrete on top of synthetic liners to mitigate the problem of instability of protective soil covers. The application is based on remedial actions taken at a Superfund site which included the retrofitting of drainage ditches with synthetic liner systems.

The original design called for the use of a textured geosynthetic liner with 12 inches of protective soil cover on top. During the construction phase, the required compaction was very difficult to achieve especially along the slopes of the ditches. This problem entailed a modification in the design. The modification called for the replacement of the protective soil cover with a 4 inch fibermesh concrete cover.

The economical factor makes the use of concrete covers less attractive but if an erosion prevention media is used with the soil, the concrete option will be more cost effective. In addition the weight of the concrete cover is less than that of the protective soil cover, which means that less tensile stress is exerted on the liner materials. Using a concrete cover in lieu of the protective soil cover did not change the design function of the ditch, but rather enhanced it.

BACKGROUND

Project Description

The Delaware City facility is located in New Castle County, Delaware. The facility processes Vinyl Chloride Monomer (VCM) to manufacture a Polyvinyl Chloride (PVC) resin.

A wastewater treatment system comprising six surface impoundments and two drainage ditches operates at the facility. The surface impoundments include two concrete-lined aeration lagoons, three earthen lagoons and one stormwater pond used primarily for stormwater detention. The two ditches convey stormwater and/or process wastewater.

The aerated lagoons received plant process wastewater for treatment. PVC solids used to accumulate in the bottom. The solids were periodically removed and the lagoons were periodically drained. As for the earthen lagoons, they received various materials from the facility. They also accumulated solids which were periodically excavated and disposed of. The same applied to the stormwater pond.

The drainage ditches were unlined. They conducted stormwater and wastewater sump overflows from production areas to the earthen lagoons and the stormwater pond. Periodically, solids have accumulated at several locations along the ditches.

In 1982, both VCM and Ethylene Dichloride were found in a water supply well on an adjacent property. This triggered a hydrogeological investigation to evaluate the extent of the contamination at the site. Following the investigation phase, a feasibility study was prepared to identify appropriate remedial measures to address this problem. The proposed improvements included removing and disposing of contaminated sludge and soil from the existing drainage ditches and surface impoundments, and retrofitting them with geosynthetic liners. This paper addresses the retrofitting of the drainage ditches only, namely the South Ditch.

ORIGINAL DESIGN

The South Ditch was sized to handle the 100 year - 1 hour storm. The assumed drainage area and the estimated storm flow rates were as follows:

Drainage Area:	19.96 Acres
Stormwater Flow Rate:	57.3 cfs
Ditch Design Capacity:	61.5 cfs

A typical cross-section of the ditch is shown in Figure 1.

The design called for the use of a single synthetic liner at the bottom of the ditch, after proper subgrade preparation. The ditch liner consisted of 40 mil textured high density Polyethylene (HDPE) liner and an 8 ounce nonwoven separator geofabric below it. The selection of the HDPE liner was based on compatibility testing. The liner was to be covered by one foot of soil to provide exposure protection from ultra-violet degradation, rodents, etc... The specifications required that all compacted structural fill achieve at least 90 percent of the materials maximum Standard Proctor (ASTM D-698) dry density. It also required that cohesive materials be compacted within $\pm$ 3 percent of the materials optimum moisture content as defined by ASTM D-698.

To provide for erosion protection and maintenance of the drainage ditches, the design specified the use of synthetic geotextile grid (geoweb) to be incorporated into the ditch. The geoweb was used to line the ditch above the protective soil layer. The lining was provided to prevent scour and assist in sediment removal/maintenance of the ditch.

The primary function of the ditches was to collect storm runoff at the site. Sediment and heavy PVC solids were to be removed primarily before they enter the ditches. The Operation and Maintenance of the ditches called for a quarterly inspection to observe any erosion problems and remove sediments in excess of six inches to maintain the channel's hydraulic capacity.

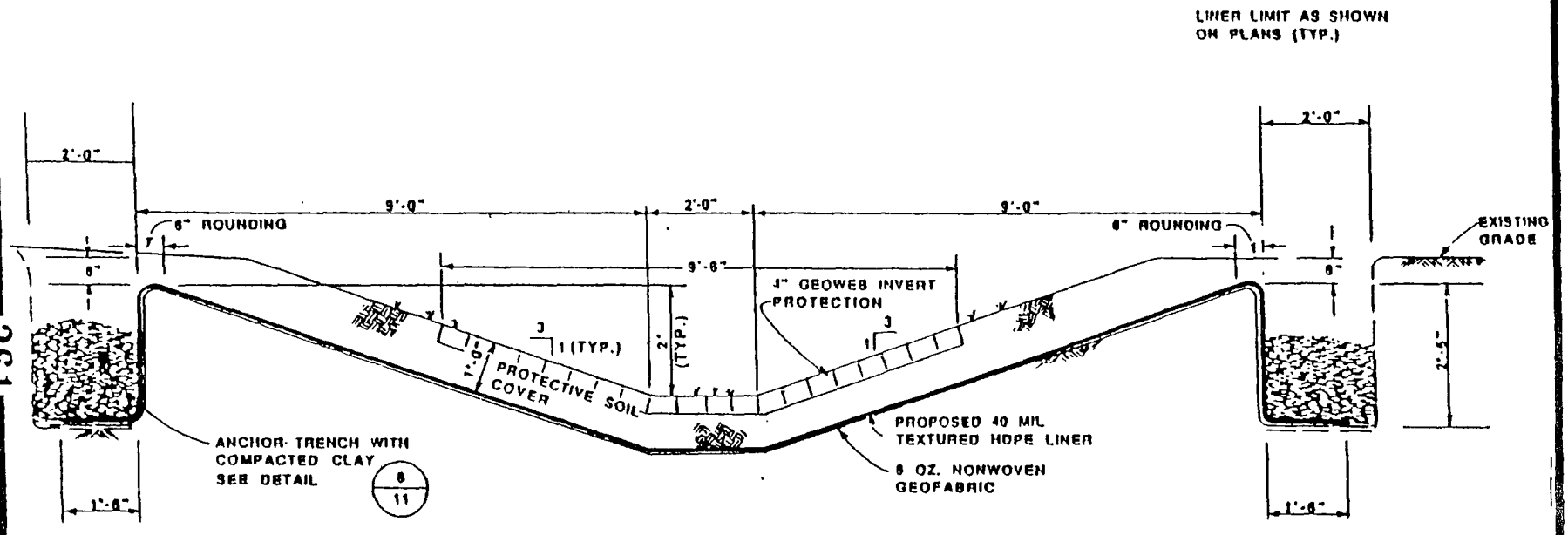

Figure 1
South Ditch
Typical Section

THE PROBLEM

Discussion

During the construction of the South Ditch, several problems were encountered with the placement of the protective soil cover. These problems occured after periods of rainfall which saturated the placed protective cover. Since the 40-mil textured HDPE liner was located beneath the soil cover, water which infiltrated the soil layer was contained by the impermeable geomembrane. The accumulation of water between the soil-geomembrane interface created two problems:

1. Achievable compaction of the soil cover was reduced because of the increase in water content above that of optimum.

2. A slip surface was created at the lubricated soil-geomembrane interface.

A select backfill material was utilized to construct the protective soil cover. The gradation of the select material is outlined in Table 1. The maximum dry density of the soil as determined by the Standard Proctor Test was 119.2 lbs/C.F. The optimum water content at the maximum dry density was 13.4 percent. During the construction of the protective soil cover, moisture content of the soil increased to more than 20 percent. This significantly reduced the achievable dry density of the soil. As a result, the required 90 percent compaction of the soil layer could not be achieved.

After storm events at the site, minor slope failures along the protective soil cover occurred. The soil would slough down the slope sometimes exposing the HDPE liner. This suggested some type of slope instability. It is believed that as water infiltrated the protective soil cover and accumulated above the HDPE liner a slip surface was created at the soil geomembrane interface. It is estimated that the friction angle at the soil-geomembrane interface was reduced from approximately 28° to as low as 10° - 15°. Basic soil mechanics tells us that the friction angle of the interface must at least be as great as the angle of the slope itself. In this case a 3:1 slope corresponds to 18.4°. Therefore, without slope stability calculations, it can be seen that a failure would occur at the reduced friction angle. As outlined below, calculations were performed to confirm the slope instability. As seen from these calculations, the factor of safety against slippage along the slope was reduced from 1.6 to 0.8 at the estimated reduced friction angle.

TABLE 1

Gradation Analysis for
the Select Backfill Material
at the South Ditch

SIEVE SIZE	PERCENT PASSING
1 1/2"	100
1"	98.3
3/4"	97.5
1/2"	96.1
3/8"	95.3
#4	93.5
#10	89.7
#20	80.6
#40	58.9
#60	41.5
#100	31.2
#140	27.9
#200	24.3

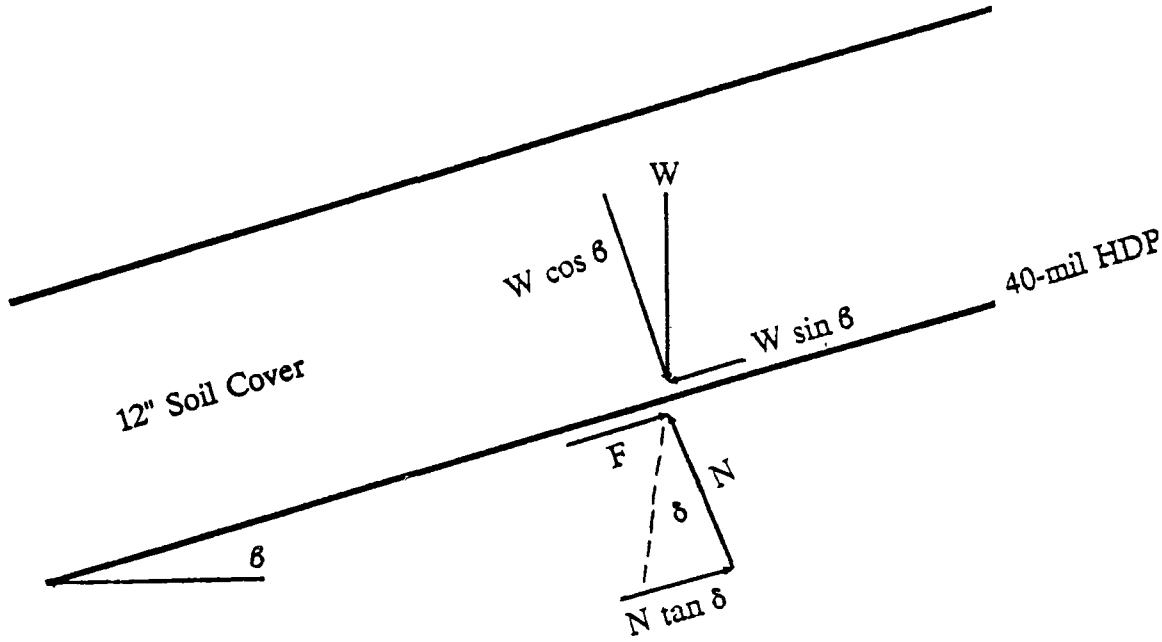

FIGURE 2

Partial Cross-Section of South Ditch With Soil Cover

<u>Calculations</u>

Given:

θ = Slope Angle = 18.4°
δ_d = Friction Angle of Soil at Dry Conditions = 28°
δ_s = Friction Angle of Soil at Saturated Conditions = 15°

Analysis:

Resisting Force = F = N tan δ = W cos θ tan δ
Driving Force = W sin θ
F.S. against Sliding = Resisting Force/Driving Force
= W cos θ tan δ/W sin θ
Factor of Safety (F.S.) = tan δ/tan θ

a) Soil at dry conditions
F.S. = tan 28°/tan 18.4° = 1.60
Required F.S. = 1.2

b) Soil at wet conditions
F.S. = tan 15°/tan 18.4° = 0.8
Required F.S. = 1.2

THE SOLUTION

Discussion

The problem of the soil sliding on the surface of the textured HDPE liner required a modification to the South Ditch design. This modification entailed the replacement of the protective soil cover with a four inch fibermesh concrete cover. Fiber expansion sealed joints were to be placed every 12 linear feet of the ditch. An eight ounce nonwoven, needle punch geotextile was to be installed between the concrete cover and the HDPE liner to absorb any moisture which may leak through expansion joints or cracks in the concrete. The laboratory filtration tests conducted on woven and nonwoven geotextiles showed that nonwoven material exhibit the best overall behavior. The mass removal efficiency was found to range from 2 to 29 percent for run durations ranging from two hours to seven hours. The size removal efficiency for 1.0 μm diameter particles ranged from nil to 56 percent.

A typical cross-section of the modified ditch design is shown in Figure 3.

Design Calculations

In order to determine the stability of the concrete cover on top of the liner, a tensile stress analysis was performed for the HDPE liner, in addition to a comparative weight analysis between the concrete cover and the protective soil cover. Finally, an analysis was done to verify that the concrete cover will not slide on the HDPE liner.

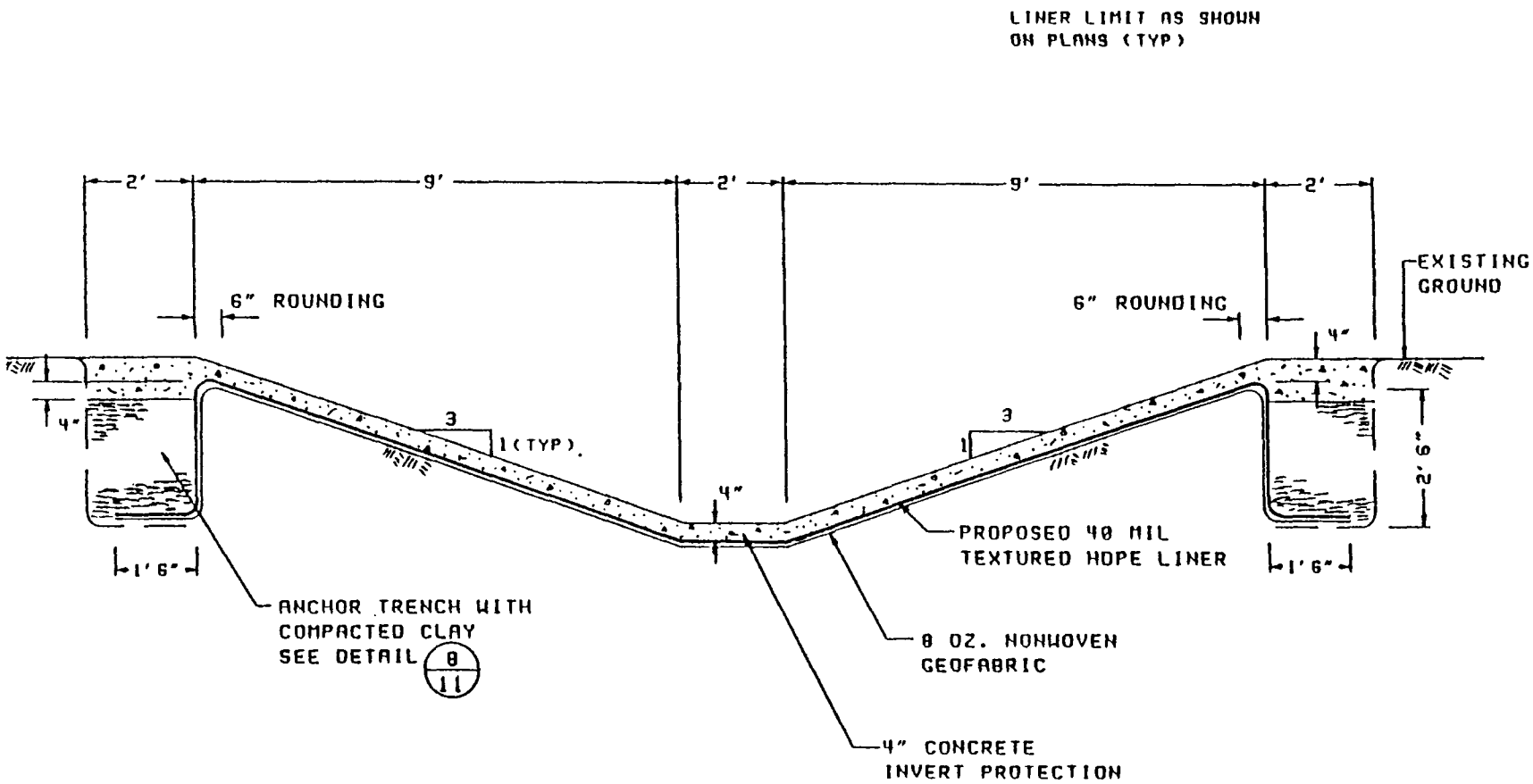

Figure 3
Modified South Ditch
Tupical Section

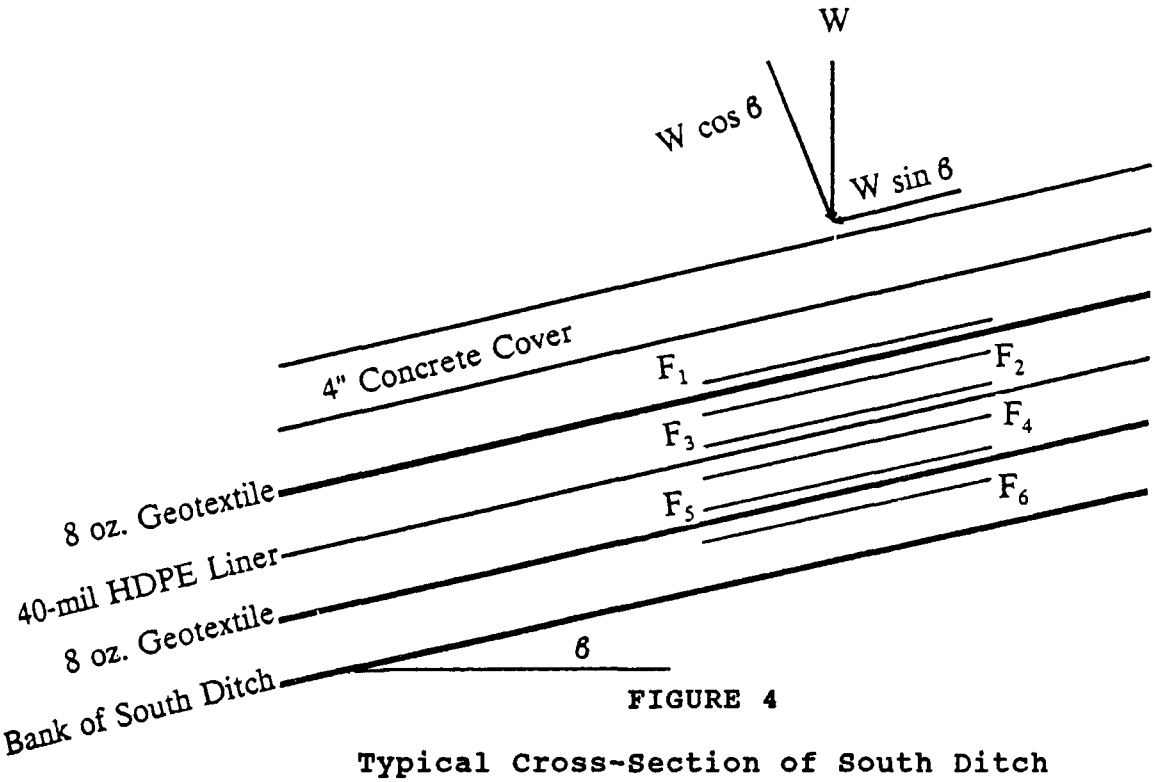

FIGURE 4

Typical Cross-Section of South Ditch

1. Weight Analysis

Given:

Soil Depth	=	1 ft.
Soil Wet Density	=	119.2 pounds per cubic feet (pcf)
Soil Compaction	=	90% Standard Proctor
Concrete Depth	=	4 in.
Concrete Density	=	150 pcf
Ditch Width	=	20 ft.

Analysis:

Actual Soil Density	=	119.2 x 0.90	= 107.3 pcf	
Soil Weight	=	107.3 x 1 x 20	= 2146 lbs./ft.	of ditch
Concrete Weight	=	150 x 4/12 x 20	= 1000 lbs./ft.	of ditch

2. Tensile Stress Analysis

Given:

Concrete Density = 150 pcf
Concrete Depth = 4 in.
θ = Slope Angle = 1 V to 3 H = 18.4°
δ_1 = Friction Angle Concrete to Geotextile = 30°
δ_2 = δ_3 = δ_4 = δ_5 = Friction Angle Geotextile to Liner = 23°
δ_6 = Friction Angle Geotextile to Subbase = 25°
Slope Length = 9.5 ft.
HDPE Yield Stress = 95 lbs./in.
Geotextile Yield Stress = 180 lbs./in.

Analysis:

W = Weight of concrete cover applied on the face of the slope
= 9.5 x 4/12 x 150 = 475 lbs./ft.
$W \cos \beta$ = 475 cos 18.4 = 451 lbs./ft.
$W \sin \beta$ = 475 sin 18.4 = 150 lbs./ft.
F_1 = Shear force above the upper geotextile
= $(W \cos \beta) \tan \delta_1$
= 451 tan 30° = 260 lbs./ft.
F_2 = Shear force below the upper goetextile
$(W \cos \beta) \tan \delta_2$
= 451 tan 23° = 191 lbs./ft.

Since $F_1 > F_2$ then the geotextile is in tension
Liner Stress = (260 - 191)/12 = 5.75 lbs./in.
F.S. = Factor of Safety = Yield Stress/Actual Stress = 180/5.75 = 31
Required F.S. = 10

F_3 = Shear Stress above the 40 mil textured liner
= $(W \cos \beta) \tan \delta_3$
= 451 tan 23 = 191 pcf.

F_4 = Shear stress below the 40 mil textured liner
= $(W \cos \beta) \tan \delta_4$
= 451 tan 23 = 191 pcf

Since $F_3 = F_4$, the geomembrane does not take any tensile stress. It is in pure shear.

F_5 = Shear Stress above the lower geotextile
= $(W \cos \beta) \tan \delta_5$
= 451 tan 23 = 191 pcf.
F_6 = Shear stress below the lower geotextile
= $(W \cos \beta) \tan \delta_6$
= 451 tan 25 = 210 pcf

Since $F_5 < F_6$, no tensile stress is taken by the lower geotextile

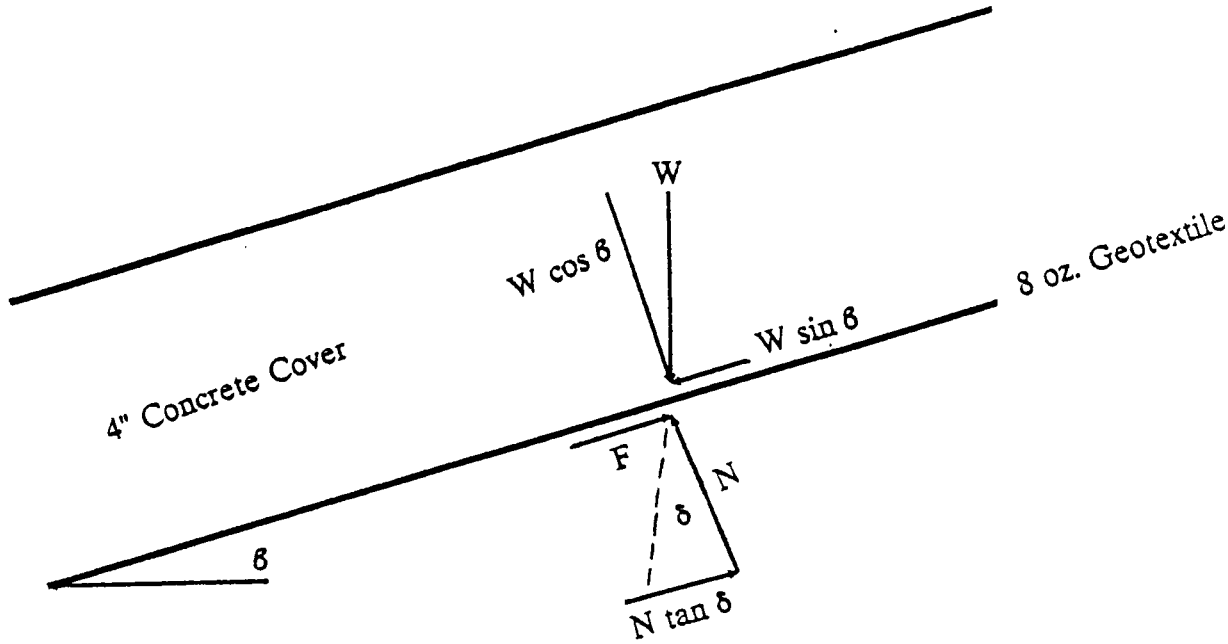

FIGURE 5

Partial Cross-Section of South Ditch With Concrete Cover

3.. Sliding Analysis

Given:

β = 18.4°
δ_1 = 30.
δ_2 = δ_3 = δ_4 = δ_5 = 23°
δ_6 = 25°

Analysis:
F.S. against sliding = Resisting Force/Driving Force
= tan δ/tan β (See Page 6)

Factors of Safety Against Sliding

a) Between concrete cover and geotextile
F.S. = tan 30°/tan 18.4° = 1.74
Required FS = 1.2

b) Between geotextile and geomembrane
F.S. = tan 23°/tan 18.4 = 1.3
Required F.S. = 1.2

c) Between lower geotextile and soil subbase
F.S. = tan 25°/tan 18.4° = 1.4
Required F.S. = 1.2

Construction

The modified design aimed to have a ditch which is watertight, moderate in cost, strong and durable, provide maximum hydraulic efficiency and have a reasonable amount of flexibility. Concrete, composed of selected aggregates with proper control of placing, finishing, and curing will require minimum maintenance and have a long service life.

1. The Concrete Mix

   The modified design included well graded sand in the concrete mix to ensure a reasonable good finish. In addition, pea gravel (No. 4 or 3/16 to 3/8 in.) content of the mix was reduced to about 5 percent to improve the finishability of the concrete. As a rule of thumb, the maximum size of aggregate should not be greater than one-half the thickness of the lining. In addition, the concrete was to placed by hand and screeded from the bottom to the top of the slope. A slump of 2 to 2 1/2 inches was specified for this application.

2. Reinforcement

   Though steel reinforcement was not required, the modified design required the addition of Fibermesh fiber to the concrete mix. Fibermesh is a concrete engineered fiber composed of virgin polypropylene which provides protection against nonstructural cracks in concrete, increases impact capacity, reduces permeability, adds shatter resistance and can eliminate the need for welded wire fabric used for crack control. Fibermesh fibers provide dimensional stability by reducing intrinsic stresses or relieving them until the concrete has developed sufficient integrity to sustain the stresses without cracking. The reduction of early age crack formation substantially reduces the number of weak planes and potential future crack formation.

3. Placing the Concrete Cover

   A protective layer of geofabric was placed on the HDPE liner. After placing the required forms above the geotextile, concrete was dumped and spread by hand on the sides and bottom. Screed guides were laid on the geofabric and the concrete was screeded up the slope to proper thickness. One or two passes with a long-handled steel trowel completed the finishing. Transverse grooves were cut at 12-foot intervals, and the lining was cured by use of solvent-based concrete curing compound with at least 20 percent solids.

   Since the concrete cover was constructed by hand, concrete was placed in alternate panels to facilitate placing, finishing and curing operations. Overall shrinkage cracking was reduced

since enough time elapsed before placing the intervening panels.

4. Contraction Joints

Transverse contraction joints were provided in the concrete cover by cutting grooves in the upper surface of the slabs while the concrete was still plastic. As a result, shrinkage cracks will be largely confined to the location of these grooves. To maintain the shape and the function of the contraction joints, the modified design called for placing a sealant in the grooves. All joints were sealed with Sikaflex, a moisture-cured, 1-component, polyurethane-base, non-sag elastomeric sealant. This sealant is highly elastic and it cures to a tough, durable material with exceptional cut and tear resistance. In addition, Sikaflex exhibits excellent adhesion and resistance to aging, weathering, and chemical action.

Cost Analysis

A comparison is presented below to compare the cost of using soil or concrete for invert protection.

1. Using Soil

Given:
Ditch Length = 1 ft.
Ditch Width = 24 ft.
Soil Depth = 1 ft.
Cost of Soil (including placement and compaction) = $ 7.00/C.Y.
Cost of installed geoweb (to be used for soil protection) = $ 1.50/S.F.

Analysis:
Volume of Soil = 24 x 1 x 1 = 24 C.F./ft. of ditch required
= 0.9 C.Y./ft. of ditch
Total Cost of Soil = 0.9 x 7 = $6.3/ft. of ditch
Total Cost of Geoweb= 24 x 1.5 = $36/ft. of ditch
Total Cost per ft. of Ditch = 6.3 + 36 = $42.30

2. Using Concrete

Given:
Ditch Length = 1 ft.
Ditch Width = 24 ft.
Concrete Thickness = 4 in.
Cost of Concrete with Fibermesh (including placement, leveling, finishing etc ...) = $70/C.Y.
Cost of Geofabric (including placement) = $3.00/S.Y.

Analysis:

Volume of Concrete Required	= 24 x 4/12 x 1
	= 8 C.F./ft. of ditch
	= 0.30 C.Y./ft of ditch
Total Cost of Concrete	= 0.30 x 70 = $21/ft. of ditch
Amount of Geofabric Required	= 24 x 1
	= 24 S.F./ft. of ditch
Total Cost of Geofabric	= 2.67 x 3 = $8/ft. of ditch

Total Cost per ft. of Ditch = 21 + 8 = $29

CONCLUSIONS

New construction often justifies putting the liner on the prepared soil subgrade and then concrete on top of it. This can be a viable alternative to mitigate problems associated with soil invert protection construction. As outlined in this paper, concrete covers have the following advantages:

1. Their application can be more economical when compared to soil reinforced with an erosion prevention media.

2. Concrete weight can be less than the soil weight, depending on the depths, which will translate into less tensile stress exerted on liner materials.

3. Concrete has a good factor of safety against slippage along liner slopes and to a lesser degree on earthen slopes.

4. The use of proper construction materials, (concrete mix, curing compound, sealant, etc...), and methods reduces maintenance work and provides long service life.

As for disadvantages, the forming for concrete placement can be difficult because the liner system cannot be punctured. In addition, concrete covers will not function properly on long, steep slopes.

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Sika Corporation, "Sikaflex-1a, Technical Data", February 1986.

U.S. Environmental Protection Agency, EPA/625/4-89/022, "Requirements for Hazardous Waste Landfill Design, Construction, and Closure", August 1989.

U.S. Department of the Interior, Bureau of Reclamation, "Concrete Manual", 1975.

PHOTO RECORD

PHOTO 1 - Saturated Surface of Protective Soil and Erosional Damage in South Ditch

PHOTO 2 - **Water Retained at the Soil-Liner Interface Even Though the Contractor Removed Water From Liner Surface Prior to This Picture Being Taken**

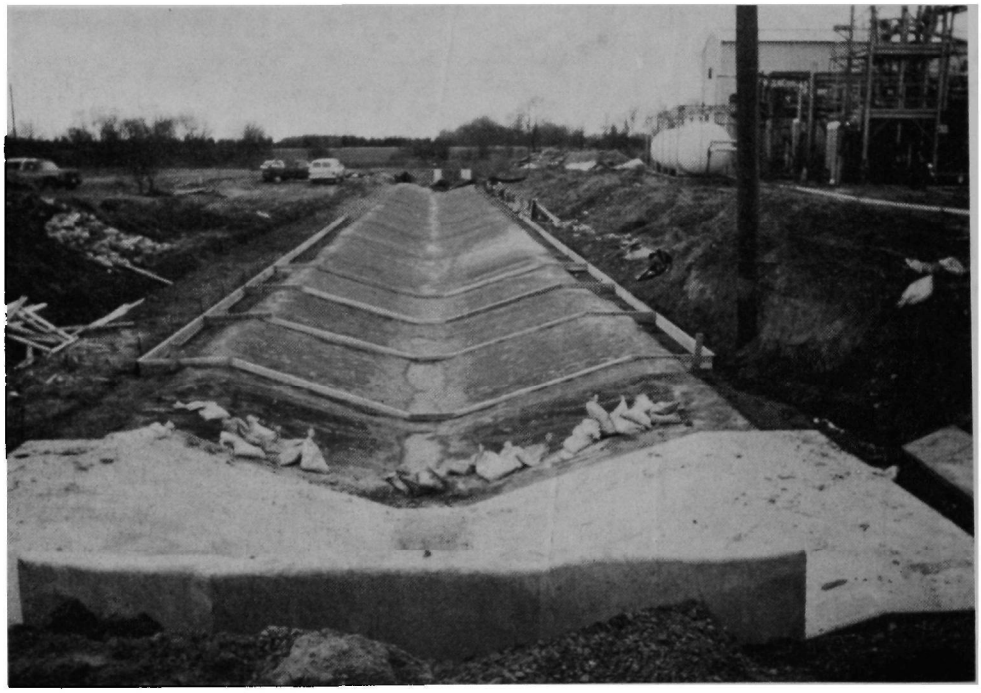

PHOTO 3 - **Wooden Forms Placed Along Length of South Ditch in Preparation of Concrete Pours for the Invert Protection**

PHOTO 4 - **Using the Back of the Rakes in Construction to Prevent the Concrete From Becoming Segregated and to Protect the Liner From Being Punctured**

PHOTO 5 - **South Ditch Completed**

A Case Study of Change Orders at a Superfund Site

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Houston, Texas

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INTRODUCTION

PROJECT OVERVIEW

The remediation of the Geneva Industries Superfund Site, as specified in the Record of Decision (ROD), consists of two phases. The first is the source remediation (the removal of PCB contaminated soils to an action level) and the second is the groundwater remediation (the pumping and treatment of contaminated groundwater to an action level). The source remediation phase of this project has been completed and the groundwater phase is in design at this time. This paper describes the work completed to date.

FOCUS OF PAPER

When the Notice to Proceed was issued on May 23, 1988, the prime contractor for the Geneva project expressed confidence that the 331 days allowed in the contract would be more than adequate. Two years and two months later, after court injunctions, material overruns, and construction delays, the site was accepted and a Certificate of Completion was issued. The project was finished 430 days past the originally projected completion date and more than 27 percent over the initial contract price.

The focus of this paper is to examine the causes of these cost overruns and time delays and analyze them to develop some lessons learned.

BACKGROUND

SITE HISTORY

The Geneva Industries site is a 13 acre tract located at 9334 Caniff Road in Houston, Harris County, Texas immediately adjacent to the corporate limits of the city of South Houston (See Figure 1). The site is an abandoned refinery which manufactured a variety of organic compounds, including polychlorinated biphenyls (PCBs) from 1967 to 1973. Geneva Industries declared bankruptcy on November 26, 1973. From 1974 until the facility was closed in 1980, several corporations continued recovery operation for biphenyls and naptha at the Geneva facility. The current owner purchased the property in May of 1982 to salvage the equipment from the site for resale.

Numerous spills over the history of the plant resulted in several areas of contaminated soil on the ground and in the adjacent drainage ditch. An EPA investigation team found soils containing up to

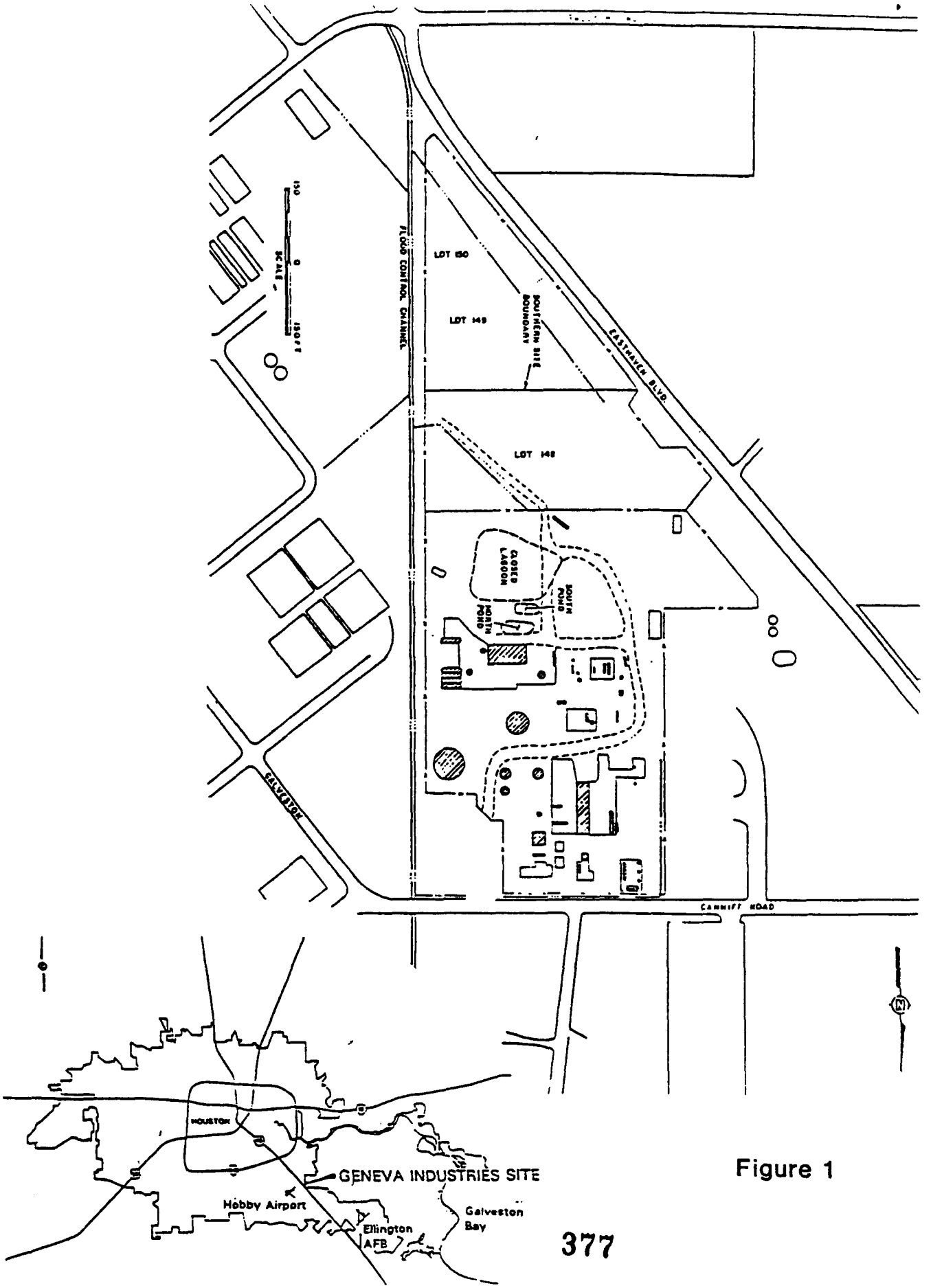

FLOOD CONTROL CHANNEL
LOT 150
LOT 149
SOUTHERN SITE BOUNDARY
EASTHAVEN BLVD
LOT 148
CLOSED LAGOON
SOUTH POND
NORTH POND
GALVESTON
CANNIFF ROAD
SCALE
150
0
150 FT
HOUSTON
GENEVA INDUSTRIES SITE
Hobby Airport
Ellington AFB
Galveston Bay

Figure 1

9,000 parts per million (ppm) PCB on the site, and up to 104 ppm in the drainage paths leading off-site. In addition to PCB, many other hazardous and/or toxic compounds, including PNA's and TCE's, were quantified in the soil on the site. A Planned Removal was performed during the period from October 1983 to September 1984. Although the removal actions mitigated the immediate hazards to human health and the environment, they did not address the long term problems. As a result of an HRS (hazard ranking system) score of 59.46, the site was placed on the National Priorities List (NPL) in September 1983, making it eligible for funding under the Superfund program.

In December of 1983, the EPA awarded the Texas Department of Water Resources (precursor to the Texas Water Commission) a grant to execute a remedial investigation and feasibility study (RI/FS) at the Geneva Industries site. This study was completed in May of 1986 and the EPA issued a Record of Decision (ROD) on September 18, 1986. The source control portion of the ROD specified, in part, the removal and off-site disposal of drums, surface structures, contaminated liquids, and all soils contaminated to a level greater than 50 parts per million of PCB's. (This ROD and the subsequent design were pre-Land Ban.) The Texas Water Commission (TWC) received a grant for the design of the remedy in March of 1987 and the design was completed in November 1987.

CONSTRUCTION HISTORY

EPA awarded construction funds for the Geneva project in December 1987. A contract for the work was awarded on April 8, 1988 for 16.1 million dollars ($16.1M). The winning Contractor planned to remove the contaminated soil to an approved landfill site in Alabama. The Notice to Proceed for field work was issued on May 23rd, on which date the Contractor immediately began mobilizing. By July 15th all the support facilities were in place and clearing and grubbing and dismantling of structures began. The schedule called for excavation of contaminated soil to begin on August 1st.

During this time, EPA was questioned by officials from the State of Alabama as well as Alabama Congressional representatives concerning the shipment of wastes from the Geneva site into Alabama. On July 22, 1988 EPA directed TWC to delay shipping wastes pending resolution of the Alabama inquiries. Thus began a series of delays, lasting over the following three months. The causes of these incidental delays included compliance difficulties by the landfill in Alabama and efforts by the State of Alabama to prevent the shipment of wastes.

Alabama obtained a temporary restraining order, issued on October 21, 1988, restricting EPA from spending federal funds to implement the ROD. A preliminary injunction, for the same purpose, was issued on October 31, 1988. This put the project in an indefinite state of delay. TWC and EPA choose to continue the project in a state of delay rather than terminate the remediation contract. On November 22, 1988, TWC directed the contractor to partially demobilize from the site. In December, the court issued a permanent injunction, thus extending the delay.

The delay continued until June 7, 1989, when the injunction was overturned. On June 14, 1989, TWC directed the contractor to resume work effective June 26th. After re-mobilizing and re-training personnel, production runs began on July 12, 1989 to the landfill in Alabama. The excavation of contaminated soils was completed on September 20, 1989. The amount excavated exceeded the bid amount by about 32 percent. The completion of back-filling the excavation was completed on January 18, 1990. Construction of the clay cap was completed the first week in June. Final completion of the project was June 20, 1990.

SCOPE OF WORK

The scope of the work at the Geneva site was fairly straight-forward. After mobilizing to the site, the contractor began clearing operations, including the removal of structures, tanks, and foundations.

The site was then divided into one hundred 50 by 50 foot grid blocks, these being subdivided into 25 by 25 foot squares. The contractor then excavated contaminated soil to a predetermined minimum depth, tested each 25 by 25 foot square for PCB's, and continued excavating if the tests indicated a PCB content greater than the 100 ppm action level. The excavation was thus advanced in 12-inch or 6-inch increments, depending on the level of contamination, until the working area was found to meet action levels. Payment on this bid item was per ton excavated off-site, so truck scales were constructed at the interface with the "hot zone".

Since the ROD determined that it would not be economically feasible to remove all of the contaminated soils at the site, some contamination was left in place. To prevent migration of the remaining contaminants, specifications called for the construction of a perimeter bentonitic slurry trench cut-off wall. This trench was advanced nominally 30 feet below the ground surface to key into a natural clay aquitard. Thus, with lateral movement retarded by the slurry wall and downward contaminant migration blocked by the aquitard, there remained the need for a protective cover.

Construction of the slurry wall began on the north side of the site, away from the main excavation. Upon completion of the removal of contaminated soils, the excavation was back-filled in compacted lifts with imported clayey soils. Back-filling continued simultaneously with the construction of the slurry wall. The site was back-filled above the original site elevation, to ensure positive drainage off-site.

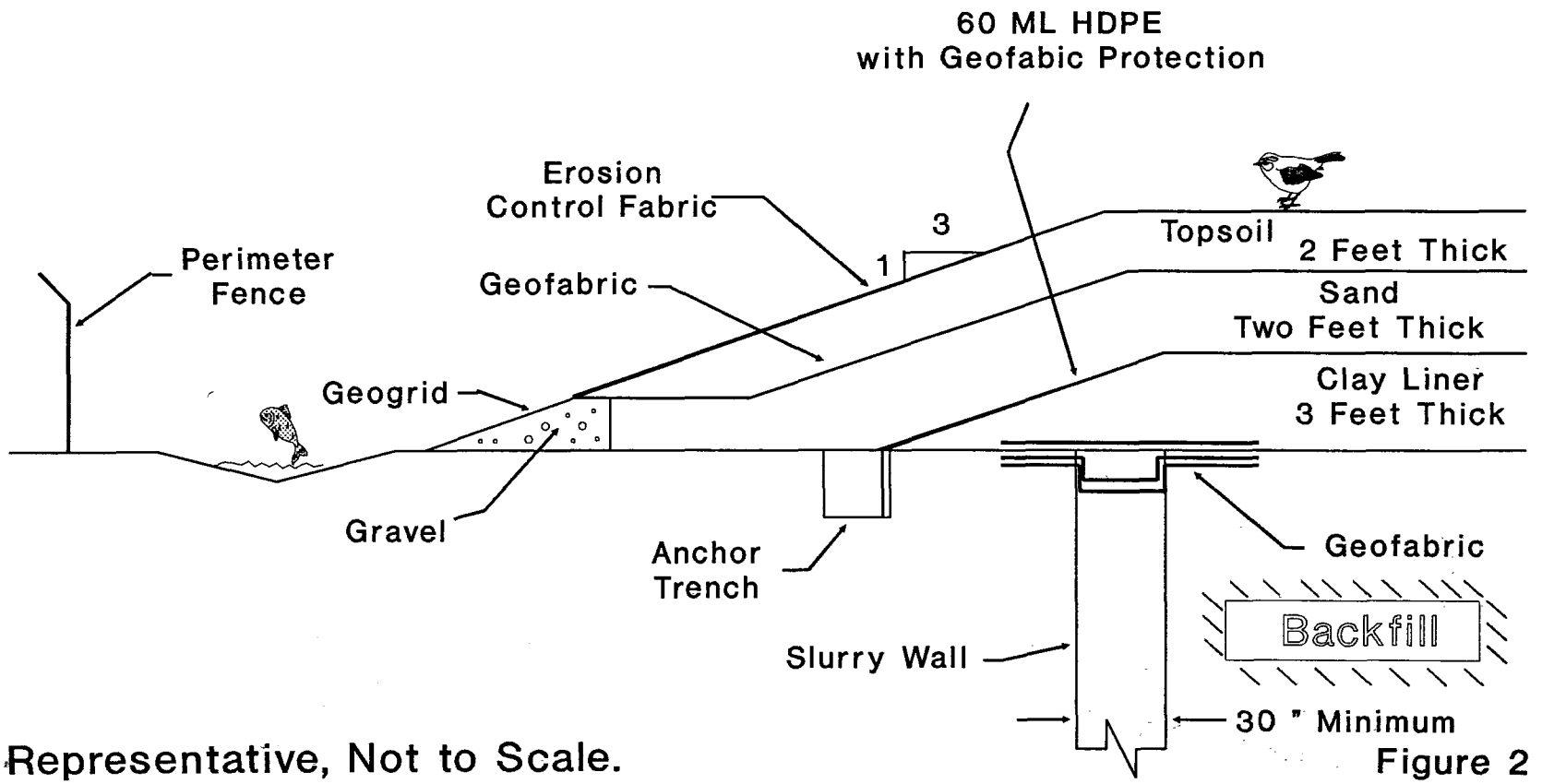
Upon completion of the back-fill and slurry wall, a final protective cap was constructed. This consisted of a layer of low permeability clay atop the general back-fill, a geo-textile fabric to act as protective barrier, 60 ml continuous HDPE impermeable liner, a geo-textile fabric, a layer of sand for drainage, geo-textile filter fabric to protect the sand from infiltration by the overlying topsoil, and topsoil, which was seeded and watered to promote a protective vegetative cover. The surface of the cap has a slope of about 2 to 5 percent and a side slope of about 3 horizontal to 1 vertical. Runoff is collected in a cap perimeter drainage ditch, which discharges to an adjacent flood control ditch. A permanent security fence was constructed around the perimeter. A cross section showing the final cap details is provided as Figure 2.

CHANGE ORDER HISTORY

There were a total of 32 changes to the original scope of work, authorized through change orders to the contract, resulting in both debits and credits. From the original contract price of $16.1M, the cost of the work increased to $20.5M. There were a total of 25 debit and 7 credit change orders. This includes a $710,300 credit change order adjusting the original bid price for underruns in specific line item bid quantities. The twenty-five debit change orders came to a total of $5.1M, while the credit change orders, including the adjustment for underrun quantities, came to a total of $736,000. A graph illustrating the cumulative costs of the project is provided as Figure 3.

Figure No. 4 illustrates the cumulative costs of just the change orders. Change Order Number 17, marked on the figure, is primarily for an increase in the volume of contaminated soil excavated and removed to the approved landfill in Alabama. Change Order No. 23 is also marked on the figure, and is for a partial reimbursement of costs associated with the Alabama lawsuit delay. The change order adjusting the cost of the project to reflect final quantities installed (material underruns) is marked on the figure as Change Order No. 31. Finally, the last change order on the figure, Change Order No. 32, is for the previously unsettled portion of the costs associated with that delay.

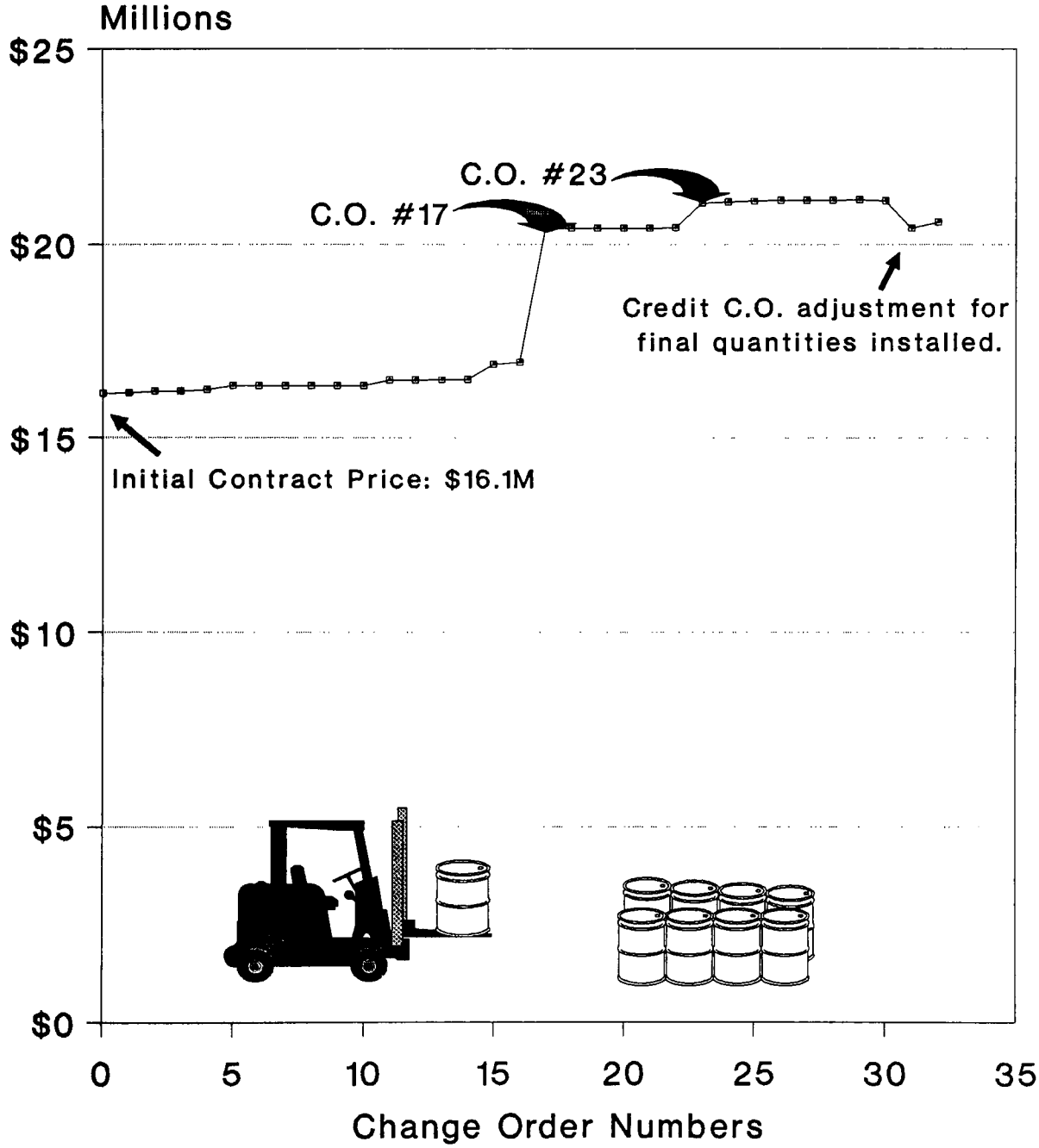
Geneva Industries Superfund Site
Cross Section of Final Construction



Representative, Not to Scale.

Figure 2

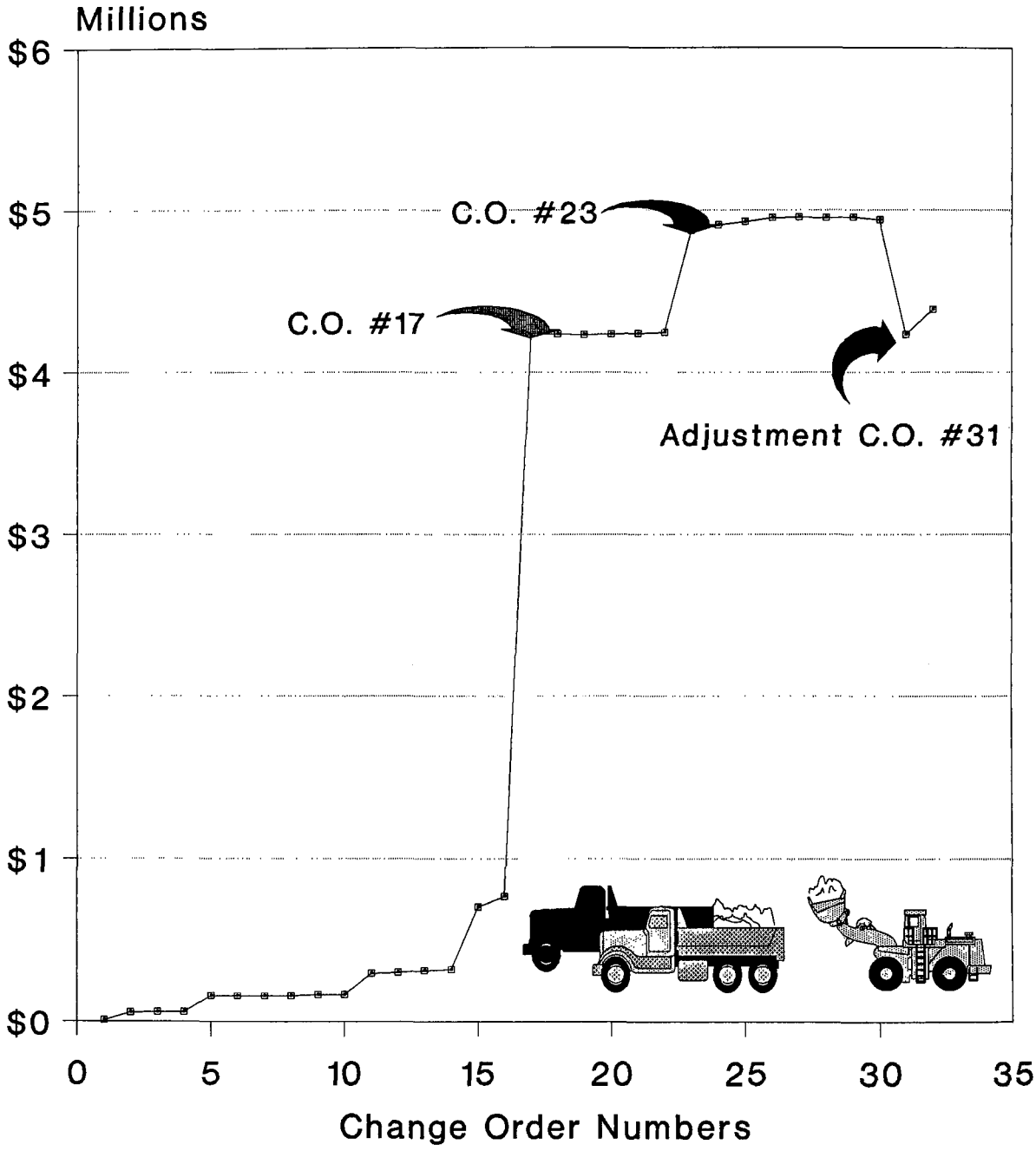
Geneva Industries Superfund Site
Cumulative Project Costs



Final Project Cost: $20.5M

Figure 3

Geneva Industries Superfund Site
Cumulative Change Order Amounts



Original Contract Amount: $16.1M

Figure 4

DISCUSSION

BIG PICTURE OF C.O.'S ON THIS PROJECT

Change orders are the result of a modification in the scope of work that is either desired by the owner or the contractor, for their own benefit, or are due to some changed condition encountered during the post-award planning or the construction stages. Such modifications are negotiated in advance and authorized using field orders, and then are finalized through the change order process. The modifications may include changes in project cost, changes in project schedule, or both. An increase in the project schedule that is allowed by a change order will usually include costs associated with those additional days (fixed costs).

Changed conditions on any large project can be expected, but this seems especially so for a Superfund project. The nature of a Superfund site is that so much of the problem is hidden from view. The field studies conducted to document the extent of contamination, and therefore the amount of work to be done during remediation, is a forensic science, and an imperfect one. Relying on a limited number of small diameter drilled core holes, limit use geo-magnetic or other fledgling technologies, and the examination of aerial photographs and plant documentation rarely provides as complete a picture as is desired or necessary to predict the work ahead.

Excessive changed conditions during construction, with their related costs, are particularly harmful to Superfund projects. Budgets and schedules at these sites are critical due to the long range planning and budget goals associated with the Superfund program. The high unit costs attendant to hazardous waste remediation means that changed conditions can quickly result in significant changes in project costs. The nature of the work also means that such changes in scope can delay the completion of the project. At Geneva, there was the additional circumstance of the work being put into an indefinite period of delay due to legal actions brought against the project by the State of Alabama.

SORTING THE C.O.'S

The thirty-two change orders executed for the Geneva Industries Superfund project were the result of a wide variety of circumstances. For the purpose of this paper, the change orders have been grouped into five general categories, relating each of them to a type of cause. These are:

Unknown Conditions: These are conditions completely unanticipated in the plans and specifications, that once discovered, resulted in additional work or services. Examples of unknown conditions encountered during the project include:

- contaminants discovered in areas previously thought to be clean;
- high PCB content sludge discovered in existing tanks that were thought to be empty; and
- the discovery of buried drums outside of drum storage areas.

Changed Conditions: This relates to work that was anticipated in the plans and specifications, but changed in some manner that resulted in additional work or services. This category does not include changed quantities. Project specific examples include:

- improvements to the design, including gates, drainage structures, water treatment plant, etc.;
- an increase in the State of Alabama waste disposal tax;
- additions to the design, such as riser casings for planned pressure relief wells; and
- changes in contractor services over holidays, etc.

Changed Quantities: This is a subset of Changed Conditions, and relates to work that was anticipated in the plans and specifications, was bid by unit price and quantity, and an increase or decrease in the bid quantity was experienced. The changed quantities change orders for this project included:

- an increase in the estimated bid quantity for clearing and grubbing;
- an increase in the estimated bid quantity for demolition and removal of structures;
- a large increase in the estimated bid quantity for the primary work of excavating, transporting, and disposing of the PCB contaminated soils;
- an increase in the estimated bid quantity for the construction of the slurry wall; and
- a decrease in the estimated bid quantities for specific elements of the permanent cover at the site.

Weather Related: The contract allowed for redress in the case of unusual inclement weather that effected the work at the site. This category relates to costs associated with both the increased cost of work due to adverse weather and the fixed costs associated with the impact on the schedule due to weather related delays. The weather impacting this project included a hurricane, a tropical storm, and an unusually wet winter during which moisture sensitive work was attempted.

Delay Related: This relates to all costs associated with the delay caused by the aforementioned lawsuit brought against the project by the State of Alabama. These costs included:

- the basic costs of maintaining a skeletal staff and facility at the site during the delay;
- an additional increase in the disposal tax in Alabama; and
- the cost of storing geo-fabrics that had been ordered just before the delay went into effect.

The change orders had the potential of changing either the cost of the work, the schedule or both. If the schedule was altered, all associated costs were accounted for in the change order.

ANALYSIS

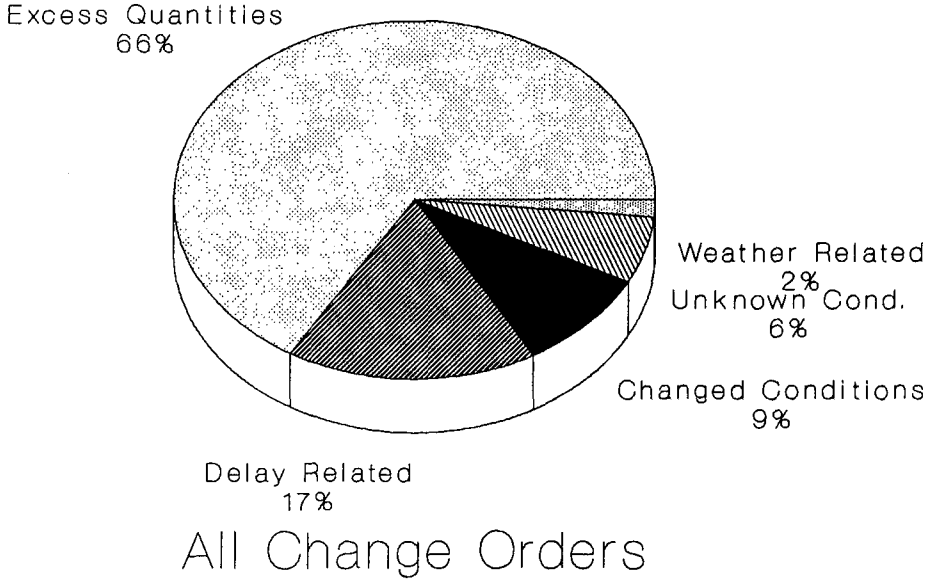
MAJOR COST ITEMS

A comparison in the cost of each type of change order as a percent of the cumulative cost of all change orders is provided on Figure 5. (Please note that this comparison includes credit change orders as well.) Discounting the anomalous (hopefully) lawsuit related delays, conditions not anticipated at all by the specifications (such as weather delays and the discovery of piers and buried drums) accounted for only 8 percent of the costs of the change orders. Changed conditions not related to excess materials, such as improvements to the design, only comprised 9 percent of the total change order amount.

The bulk of the increase in the cost of this project was due to excess quantities of materials that were anticipated and designated in the bid specifications for removal from the site. Actually, the proportional impact of these overruns is even greater that suggested by Figure 5. When the credit adjustment for the change order for material underruns is added back in, excess quantities comprise over 70 percent of the total change order costs.

Over 90 percent of the excess material cost increases were associated with the overrun in Bid Item 12A. (This bid item was for the excavation, transport, and disposal of the PCB contaminated soils.) The bid form estimated the quantity to be removed at 47,400 tons. The final quantity was 62,293 tons, an increase of over 31 percent by weight. In addition to the increase costs due to the excavation,

Geneva Industries Superfund Site
Comparison of Types of Change Orders



Includes Debit and Credit C.O.'s

Figure 5

hauling, and disposal of this excess material, there was also a significant additional cost due to higher disposal taxes on the increased material and also costs associated with increasing the project schedule.

OVERRUN OF PCB CONTAMINATED SOIL

The estimated total volume of PCB contaminated soil was derived from the contents of the Remedial Investigation (RI) report. A total of 23 borings (five of these had monitor wells installed) and 10 test pits were completed on-site during the RI. Seven additional monitor wells were constructed off-site. The RI report also indicated that additional sampling had been conducted prior to the RI by EPA during a planned removal, including sampling and sounding of tanks, and then again about the time of the RI for specialized testing. No further soil samples were taken until the start of the remedial construction activities. The last test boring was completed in October of 1984.

The Engineer developed stratigraphic cross sections from the boring and laboratory test data. From these cross sections, total volume estimates for various action levels of PCB contamination were developed. These values were increased by 30 percent to allow for data gaps. Still, the actual volume of contaminated soil removed was more than 30 percent beyond this amount. Although there is always the possibility of gross error having occurred in calculating the volumes, or in interpreting test data, all such work was subject to internal Quality Assurance and TWC/EPA review.

It is reasonable to next examine the timeliness of the field data. The deep excavation in the area of the old waste pond, the area where the deepest contamination was expected and was indeed found, was not well underway until October of 1989. This is just about 5 years after the completion of the last boring during the Remedial Investigation. It is very likely that over this period of time, the contamination continued to extend outward from its original position, thus increasing the volume of contaminated soil.

OTHER OVERRUNS

The remaining items in which overruns were experienced were insignificant in their impact on the cost of the project compared to the Bid Item 12A overrun. Clearing and grubbing ran 195 percent over the bid amount, bid by the ton. This item is difficult to estimate on any project. However, the cost of the excess clearing and grubbing comprised less than 1 percent of the total debit change orders. The remaining overruns were within the norms for exceeding bid estimates, that is within 15 percent.

ALABAMA LAWSUIT COSTS

The change order cost to the project for the Alabama lawsuit was second only to excess quantities. The project was effectively delayed eleven months. The TWC and EPA initially believed the Alabama legal actions could be overturned within a short period of time. When it was apparent that the delay would extend over several months, it was decided that demobilizing from the site, keeping a facility in place with a minimal staff, and keeping the contract in effect, was preferable to canceling the contract and having to re-bid once the lawsuit was resolved.

The most painful aspect of the Alabama delay was in coming to an agreement as to what were the costs incurred by the contractor. The delaying injunction stipulated that the project would be put on hold in all respects, and regular payments to the contractor could not be made. Upon the removal of the injunction, the contractor presented an invoice for the delay period costs. The final resolution of these costs was not reached until well over a year after the injunction was lifted and four months after completion of the work.

EFFECT OF CHANGE ORDERS ON SCHEDULE

Keeping a Superfund project on schedule is often as important as keeping it within budget. Figure 6 shows the impact of the change orders on the Geneva project schedule. It should be noted that the effect on the scheduled completion is indicated by this figure. In fact, the project was completed 72.5 days beyond this date, due to difficulties the contractor had in completing the slurry wall. By far, the vast majority of the delays experienced were related to the Alabama lawsuit. Non-lawsuit related delays comprised less than 5 percent of the total delays.

Of the non-lawsuit related days, most were due to either changed quantities or weather related delays. Time extensions for changed quantities and weather delays were very difficult to negotiate with the contractor, who felt a considerably larger number of days should have been granted. Increases in material quantities effected the schedule the most and were the most costly due to the tempo of work. Although the project schedule was extended by over a month to account for several periods of rainy/freezing weather, the costs associated with these days constituted only 2 percent of the cumulative change order costs. It is apparent that weather delays have a relatively low impact on the cost of the project compared to other change order issues.

CONCLUSIONS (LESSONS LEARNED)

RELATED TO UNKNOWN CONDITIONS

Comprising 6 percent of the cost of the total change order amount, the unknown conditions at this site proved to be a nuisance, but manageable. In hindsight, a closer inspection of the slurry wall path with respect to the location of the since removed horizontal tank structures might have resulted in the slurry wall being moved to avoid the old foundation piers. Certainly, all of the tanks still on site should have been re-inspected in the RI phase. The state of the art of geomagnetic surveys today probably could not have detected the buried drums during the RI Phase, with existing metallic structures still on-site. It may be worthwhile to conduct another survey once the site is cleared of all surficial tanks and piping.

RELATED TO CHANGED CONDITIONS

The changed conditions experienced at the Geneva site were reasonable and typical of a dynamic project this size. The bulk of the cost of this category of change orders was related to an increase in the disposal tax in Alabama, an occurrence out of the purview of the contractual parties.

RELATED TO CHANGED QUANTITIES

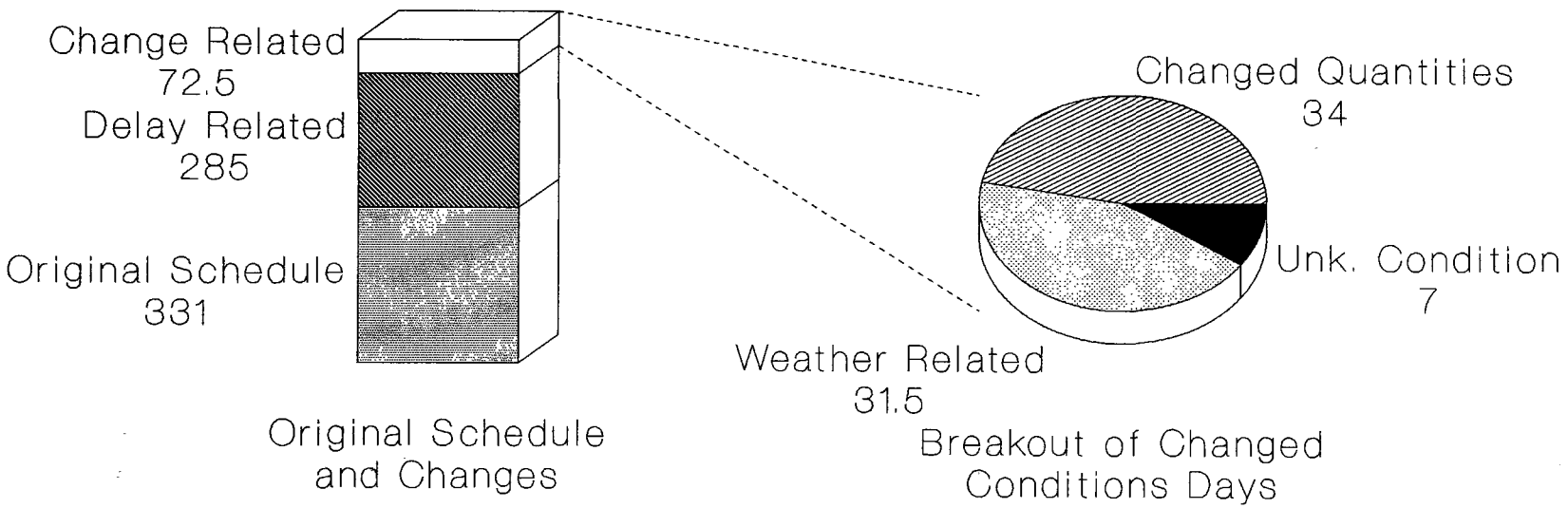
The complicated nature of Superfund work often means that each phase of the work is time consuming. Many months and often years pass between the original site investigation and the actual remediation. In this case, it was nearly five years after the RI field work was completed that real progress at the site was realized. The continuing migration of contamination over this period of time is very likely the prime reason for the large overrun in the quantity of contaminated soil that was removed from the site.

It would be advisable to include in the Feasibility Study a projection of the migration of contamination over time, providing estimates at a yearly interval of what the change in the volume of contaminated soil (or water) might be. This would understandably be difficult, especially with complicated contaminate sources, constituents, and subsurface conditions. In lieu of this, it would be prudent to call for a verification drilling and testing program when the project is close to bid. This would provide the EPA advance notice of significant changes in volumes, allowing additional funding

Geneva Industries Superfund Site

Changes to Project Schedule

(Values Shown are Calendar Days)



Original Project Schedule: 331 days
Revised Project Schedule: 688.5 days
(Work completed 72.5 days beyond this.)

Figure 6

to be arranged if necessary. Furthermore, the Engineer could ensure the change in site conditions do not adversely affect the design and would allow the bid form to be adjusted for the larger volumes to obtain a lower initial unit cost. If managed correctly, the verification sampling and testing program could run concurrently with the design and not impact the project schedule.

RELATED TO WEATHER DELAYS

It is essential that clear and definitive language be developed to cover the possibility of weather affecting the project schedule. Any weather days anticipated in the schedule should be clearly identified in the bid documents. Wording should also be provided to protect the owner (State/EPA) when the contractor is suffering from rainy weather primarily due to poor drainage practices. Better discussion of weather delays in the contract documents would have reduced the amount of time spent negotiating with the contractor days due for inclement weather.

RELATED TO THE ALABAMA LAWSUIT

Outside forces can surprise any project and put it into a state of delay. If another government body is involved in the delay, it is essential that all parties to the contract be privy to negotiations and events that transpire, which might effect the project.

The parties to the contract should come to terms immediately as to what costs would be allowed under the contract during the delay. At the end of the delay, the contractor at Geneva attempted to claim interest charges based upon the delay costs. Since interest as a cost item was not negotiated at the beginning of the delay, these claimed costs could not be allowed and the contractor filed for arbitration. Months of negotiations were required to settle the issue, costing hundreds of man-hours by both state and EPA personnel.

CLOSING

In theory, the change order process looks so neat and orderly. But the lack of specific enough language in a contract, coupled with the uncertain nature of Superfund sites, can turn changed conditions into a nightmare. And the costs are not just in increased contract price and delays in completion. The fractious nature of change order negotiations can shift the focus of the State/EPA Project Manager, the Engineer, and the contractor, and the project suffers. Change orders negotiations based upon clear and concise contract language can be relatively painless, and allow everyone to get on with the real work at hand.

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Transportation and Disposal of Denver Radium Superfund Site Waste

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INTRODUCTION

This paper is intended to describe the organizational makeup, the contract methods utilized, the contractors' methods, and as an update of the current status of the Denver Radium Superfund Site (DRSS). A very similar paper was presented in 1989 by Mr. Elmer Haight at the 10th National Conference of Superfund '89, and this paper is an updated version of that original presentation. Some background information is also presented to provide a better understanding of the overall project.

When Madam Curie discovered radium in 1898, she set in motion a chain of events which left an unwanted legacy for following generations. By the early 1900's, radium was touted for its medicinal properties and ability to destroy or inhibit cell growth, and it became widely used as a treatment for cancer. As a result, demand for radium skyrocketed, starting the radium boom of the early 1900's.

Prior to 1914, there was little or no domestic production of radium. Rather, radium-bearing ore was shipped from the United States to Europe, where it was refined. About 1914, it became evident that processing in the United States would be advantageous. The U.S. Bureau of Mines entered into a cooperative agreement with a private corporation, the National Radium Institute (NRI). According to the agreement, the NRI was to develop and operate a radium processing plant in the United States. The demand for radium grew, and new sources for radium were sought. Carnotite, a radium-bearing material, was identified in Colorado about that time, and it seemed appropriate to locate the NRI in Denver. Carnotite provided the ore from which radium was extracted by several processors in Denver from 1914 to about 1920.

The Denver radium industry remained strong until around 1920 when very rich deposits of radium-bearing ore were discovered in the Belgian Congo. The Denver producers could not compete, and the Denver radium industry closed almost overnight.

The health-related implications of radium processing were not known or considered a problem in those days. Although much of the radium was recovered, process residues containing radioactive materials were discarded.

In 1979, the Environmental Protection Agency (EPA) discovered a reference to the NRI in a 1916 U.S. Bureau of Mines report. Subsequent research revealed the presence of many sites in the Denver metropolitan area containing material requiring remedial measures. One of the sites being remediated was the location of the original NRI. This site contains about 88,000 tons of contaminated material. Studies were subsequently conducted to identify the potential hazards on all of the known sites.

There are 44 properties that have low levels of radioactive contamination that could potentially endanger public health or the environment.

The DRSS was placed on the National Priorities List in 1983. Due to the enormity and complexity of the DRSS, the EPA determined that response actions could be conducted in groups or operable units, and 11 operable units were established. Nine of the eleven operable units are being serviced by the Bureau of Reclamation's (Reclamation) transportation and disposal contractor.

The work falls under the jurisdiction of EPA's Region VIII, which is headquartered in Denver. EPA's agreement with the Department of Energy (DOE) is to provide the final studies and site investigations and to develop appropriate specifications for the excavation of the contaminated material and restoration of each of the sites to as near the original condition as possible. This is a difficult task because each property where contaminated material is located is unique. It involves open areas in some cases and in others it includes contamination in and under buildings.

Strong efforts are made during all site work to keep existing active businesses in operation. The logistics of this presents a significant challenge to DOE and their contractor, Geotech, which provides the engineering and construction oversight for the remedial action work. The work involved for each operable unit is covered by its own construction subcontracts.

Since 1988 to date, a total of 13 separate subcontracts to perform excavation loadout and reconstruction have been awarded and completed. Three are currently under way and four are scheduled in the future in order to finish this project by the fall of 1992.

INTERAGENCY AGREEMENT

During the investigation stage, EPA asked Reclamation to provide remedial action assistance in the transportation and disposal phases of the project. An Interagency Agreement was signed in September of 1988. Reclamation became responsible to contract for all aspects of the transportation of the material and disposal in a proper facility. Reclamation is providing the contract administration and construction management for the work.

Most of the overall coordination with interested and affected parties such as the owners and local, State, and Federal governments is handled by EPA personnel. Matters involving cost recovery, obtaining State of Colorado participation in funding, and working with various entities to assist in identifying and obtaining permits and licenses are handled primarily by EPA.

The matter involving cost sharing is important as it pertains to maintaining a timely schedule of work, because remedial work could not start on operable units until all agreements were finalized. Schedules were directly tied to signing of these agreements.

QUANTITIES AND LOCATIONS OF WASTE MATERIAL

Since Reclamation involvement started in 1988, the estimated total amount of material to be transported has risen from 140,000 tons to an estimated 385,000 tons used at the time the solicitation was issued. This is due to better information further defining limits of contaminated material at each site. Determining the depths and lateral extent in some cases is quite difficult. Access to some sites is limited; buildings remain in place; and the sheer magnitude of the project all make accurate computation of quantities difficult.

Of the nine operable units involved in Reclamation's transportation and disposal work, the estimate of material from the smallest unit or property within a unit is approximately 20 tons. The largest operable unit contains approximately 158,000 tons. Transportation and disposal service must be provided to a wide variety of areas from a restaurant franchise to a large scrap metal processing facility covering several city blocks.

CONTRACT INFORMATION

For the transportation and disposal work, Reclamation chose a "requirements-type" contract. "Delivery orders" are made against the contract as the work progresses. The solicitation was issued in November of 1988. Technical qualifications of the firm receiving the award were of paramount importance. Price was also of great importance. The interested firms were asked to submit separate proposals, one for technical evaluation and one for price evaluation; the technical proposals carried 60 percent of the total available points and the price, 40 percent. Technical proposals from the firms were evaluated by a committee of professionals, performing each review without discussion among themselves. Following the independent review and scoring, the committee met to discuss the individual firms' proposals. Consensus scores were arrived at for each item rated as it compared to the preestablished evaluation standard. After best and final proposals were submitted and evaluated in the same manner as the initial proposals, a contract was awarded to Chem-Nuclear Systems, Inc. (Chem-Nuclear), of Columbia, South Carolina, a subsidiary of Chemical Waste Management, Inc. Chem-Nuclear has been in business since 1969, is highly qualified in the radiological waste disposal field, and has an excellent transportation safety record for this type of material. The contract value is expected to be about $70 million if the final quantity of material is near the originally estimated quantity of 385,000 tons.

The major subcontracts involved under Chem-Nuclear's contract include rail service, trucking, and also the disposal facility. The disposal facility is Envirocare of Utah, Inc. (Envirocare), a facility located about 80 miles west of Salt Lake City, Utah.

The base contract was set up to provide for transporting and disposing material from time of mobilization through September 30, 1989. Option years include in sequence the fiscal years (October 1 through September 30) of each year until September 30, 1992. Chem-Nuclear's proposal contained slightly different prices to perform the work for each succeeding year.

The Government places delivery orders against the contract based on the quantities to be hauled and the prices submitted by the contractor for each calendar period of performance.

The quantities estimated by Geotech are "in-place" volume. Through experience, a conversion factor of 1.6 tons-per-cubic- yard was established and applied to this project. The contract includes a schedule of anticipated volumes of material to be disposed of. But, as so often is the case in this business, the actual amount of material removed varies considerably when the ground is opened and the contaminated material is literally chased. This problem, coupled with the involvement of approximately 20 different subcontracts for the excavation, has made the original schedule only a guide.

The bid schedule contains only four pay items. The most significant one is the per-ton, all-inclusive price for transporting and disposing of waste. Other items include the holding of loaded containers while waiting for waste certification test results (this is paid for by day for every day held beyond 7 days), moving empty containers from one unit to another to accommodate loading schedule changes, and return of loaded containers to the operable unit where loaded in the event the material is outside of the waste classification limits of the solicitation.

DESCRIPTION OF THE MATERIAL TO BE HANDLED

The waste is considered naturally occurring radioactive material (NORM) of low specific activity. It is not considered "radioactive" under the Department of Transportation's (DOT) definition in 49 CFR 173, but the contract requires that certain portions of those regulations be followed in

transporting waste. Much of the material looks like ordinary soil, and the debris is mainly building materials, pavement chunks, tree stumps, and similar items.

The primary radioactive contaminants include Radium-226 (Ra^{226}), found in concentrations of approximately 100 picocuries-per-gram (pCi/g) - with very limited amounts containing concentrations up to 65,000 pCi/g. There is also Thorium-230 (TH^{230}), concentrations approximately 100 pCi/g - with very limited amounts of material over this concentration.

Some NORM waste has been found to contain other nonradioactive contaminants. To date, this material has been classified as exempt from the Resource Conservation and Recovery Act (RCRA), as determined by the EPA. In order to properly dispose of this RCRA exempt NORM waste, Reclamation had to negotiate a change order with the contractor. This was accomplished and a total of 2,100 tons to date has been disposed of under the contract modification.

SAMPLING AND TESTING

The sampling and testing program set up and conducted by EPA, DOE, and Geotech for waste certification provides needed information concerning the character and composition of the waste. The representative sampling is done at the time of loading, and thus a determination can be made concerning the average concentrations of Ra^{226} and TH^{230} in the waste, and to otherwise determine if the waste is acceptable to the disposal facility. Some confirming record tests are also performed at the disposal site by Envirocare.

LOADOUT OF CONTAMINATED MATERIAL

The methods used to date for loadout have been varied and depend upon the situation at the site. Loadout of NORM material has occurred most commonly as follows: Load directly into the container within the exclusion zone with some occasional rehandling and stockpiling of the waste. The container is then frisked and decontaminated, if necessary, and released for shipment. The decontamination is performed by Geotech.

Several other specialized site specific situations have occurred. The load is dumped at the edge of an exclusion zone directly into a container. In this specialized case, the containers are also frisked to check for external contamination prior to release for shipment. The load is hauled from the exclusion zone through a "clean" area and dumped into a container. In this case, material was placed into bags and put into a front end loader bucket for the short haul to the container. In another case, material was placed from the exclusion zone into a front end loader bucket which was then covered with plastic for the short haul to the container. In all cases, this involved relatively small quantities of material. At another site, due to the existing grade and site layout, a conveyor system was installed to load material from a lower elevation directly into railcars. This system was required to be fully enclosed with shrouded downshoots and water sprinkler nozzles for health and safety concerns for prevention of airborne contaminants. During operation, numerous problems developed, primarily due to saturated material. A ramp was then constructed by the loadout contractor for direct dumping into the railcars. The conveyor system was installed, operated, maintained, removed, and decontaminated by Chem-Nuclear, the transportation and disposal contractor.

An important item to consider during specifications development is whether or not transportation and disposal should be a separate contract from remediation. A critical item, if they separate contracts, is a detailed description of the exact conditions associated with the loadout. The location, method of loadout (if appropriate), decontamination responsibility, and how the decontamination area will be finally cleaned should be well planned and specified in detail.

TRANSPORTING THE WASTE

Chem-Nuclear is transporting the majority of the material in 100-ton railroad gondola cars and the remainder in smaller containers of 20-ton capacity. The sampling and testing procedures will accommodate these containers. Samples are analyzed by the opposed crystal system (OCS) gamma-ray spectrometer. The radium concentration determined by the OCS is used to confirm that the average radium concentration does not exceed the maximum allowed by the disposal facility. Laboratory testing for TH^{230} and numerous other tests are performed as appropriate. Split samples are provided to the disposal facility for comparative testing upon their request.

As test results become available, containers are released for disposal. Note that in order to allow for holding cars, and an extended amount of time due to testing delays, a contract bid item is used to pay per day for holding cars in excess of 7 days.

Since the first delivery order, Chem-Nuclear has been working intensely at getting railroad spur tracks improved and installing new ones at several operable units. This not only involves coordination among the railroads, owners, and others, it also involves coordination with Geotech to ensure the transportation phase remains compatible with the loading operations. Railroads need to provide the necessary switches and track and also schedule availability of gondola cars.

Operable units where rail service is not available, or where it is not feasible to construct spur track into the areas, are served by trucked roll-on, roll-off, 20-ton containers.

All containers must meet DOT requirements for shipping radioactive waste. They must be closed, tight containers set aside for exclusive use for DRSS wastes. If the material is such that it will stick to the gondola, the gondola car is lined with 6-mil polyethylene sheets. All cars are filled and steel clad lids cover the entire car's top. The lids weigh about 1,200 pounds, and were originally lifted on and off by a small forklift. The contractor later designed and built a gantry crane which was used to easily lift on and off the lids. The forklift method was eventually discontinued at all sites, except for special instances.

The first lids used were called "trak-pak" and were plastic tarps supported by a network of trusses. The first hard lids referred to "NFT" or fixed lids which were purchased/developed and worked into the fleet of railcars near the beginning of the job. These lids were reusable, metal box tubing framed, and covered with metal skinned styrofoam panels.

Then, in the summer of 1990, Chem-Nuclear tried what were called "soft tops" for gondola covers. These consisted of heavier plastic covers which contained a drawstring for a snug fit on the ends of the gondolas. Due to the harsh climatological and wind conditions the railcars are subjected to, this type of soft plastic covers was discontinued.

The contractor then developed another "metal clad" lid which consisted of approximately the same frame as the "NFT" lids but additional supports were added across the frame at 2-foot intervals. The metal clad lids were constructed by combining three equivalent interchangeable sections into one lid. These lids were then covered with corrugated galvanized sheet metal.

After loading, decontamination, and lidding, the gondolas are then switched and start their journey to the disposal facility by Burlington-Northern tracks to Speer, Wyoming, where they are switched to Union Pacific to continue to Envirocare's disposal facility. The disposal facility has direct rail service and has easy truck access from U.S. Interstate Highway 80.

Material from operable units not served by rail is loaded into the 20-ton containers. Chem-Nuclear has provided a transportation terminal in Denver, located at 1960 A 31st Street, where empty containers are stored and released as needed to operable units for loading. After loading, the vehicle and container is decontaminated by Geotech, and travels back to the transportation terminal for weighing. It then proceeds to the railroad's intermodal yard for loading on flatcars for the trip to Salt Lake City, Utah. It is then picked up by truck and transported to a holding area at Envirocare to wait for test results allowing disposal. Truckers must meet stringent qualification requirements. Vehicles are inspected daily. City routes have been established to avoid residential and school areas, and all routes meet the approval of local Transportation Engineering Departments. Security at the transportation terminal is 24 hours a day, 365 days a year.

All containers are weighed using State certified scales manned by State certified weighmasters.

The problems with the transportation and disposal operation itself have been limited, largely due to the contractor's site management and coordination efforts. The significant problems which have occurred are: 1) limitations on railcar movement due to problems with coordination between multiple railroads; 2) scheduling fleet size and lead time required, and maintaining an established fleet economically for long periods of time using difficult and uncertain data as the basis for these decisions; 3) disposing of frozen material; and 4) reacting to short term schedule fluctuations in a timely manner. Even though the remedial action contracts require a weekly schedule be provided, the fluctuations are many times only predictable from 1 to 3 days in advance due to the nature of this remedial action.

To date, one claim for extra compensation has been filed alleging increased costs due to schedule fluctuations different from those portrayed in the specifications. This issue is not resolved at this time.

During the summer of 1990, Chem-Nuclear's parent company Chem Waste Management purchased Geotech, DOE's contractor. As a result, this purchase created the appearance of a conflict of interest as determined by Reclamation. This is due to the fact that Geotech is directly in control of the quantity of material being excavated and ultimately transported and disposed of by Chem-Nuclear.

Reclamation is currently seeking approval of a waiver by the Assistant Secretary of Interior as required by the Federal Acquisition Regulations (FAR) which adds oversight of the as-directed excavation operation performed by Geotech's subcontractors by an independent contractor.

DISPOSAL FACILITY

Envirocare of Utah, Inc., was chosen by Chem-Nuclear as the only operating NORM waste disposal facility in the country that can receive radium waste in bulk form. It has been used to receive material from several sources including at least 2.5 million cubic yards of mine tailings. It became fully licensed in February of 1988. After years of comprehensive studies, this disposal site was selected by DOE and the State of Utah as the best out of 29 potential sites in Utah. The facility is designed to handle over 20 million tons of contaminated material. The facility lies above a substantial clay layer which provides a good bottom seal for the cells. The percolation rate through the layer is extremely low. The facility is far from surface water or potable groundwater. The DRSS cell is excavated several feet down from the ground surface in an area about 600 feet wide by 800 feet long. It is filled layer by layer with waste until all waste under the contract has been deposited in the cell.

Railcars, as they arrive are held on Envirocare's railspur, capable of holding more than 250 railcars at one time, until official clearance to dispose of the material is received. They then proceed to the

area where the covers are removed, and the gondolas are put onto a rollover machine where each car is secured in the machine and turned over about 150 degrees to dump its contents onto a concrete pad beneath the machine. Cycle time is about 6 minutes-per-car. The waste is then loaded into dump trucks with a front loader for the 4,000-foot trip to the cell. The dumped loads are spread into approximate 12-inch lifts, moistened if necessary to facilitate compaction and control dust, and rolled with a standard roller to at least 90 percent of laboratory maximum dry density using the standard Proctor Method ASTM D-698.

All containers are decontaminated using a high-pressure washer prior to being released for return to Denver. Only the outside needs to be decontaminated, since the containers will be covered for the return trip and reused for this project. At the end of the job, the entire container, inside and out, must be cleaned as necessary for the container to be released for nonrestricted use.

The completed cell will be topped with a 7-foot layer of compacted clay which provides a radon barrier. A 6-inch layer of gravel bedding topped with 18 inches of cobbles will provide the top and side slope erosion protection. A drainage ditch and operation and maintenance road will surround the cell. It is designed to be relatively maintenance free for up to 1,000 years.

The average moisture is 5 inches per year so downtime due to heavy rains or snow is minimal. Long term assurances by trust agreement are provided for the continued maintenance of the facility. The facility is appropriately licensed in accordance with the requirements of 40 CFR 192(a), fully approved by the State of Utah, and is under their constant monitoring and inspection. Disposal activities are in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Section 121(d)(3). Groundwater and air monitoring measures are thorough.

Problems have occurred at the disposal site due to material becoming frozen during the shipping process. Upon attempting to dump frozen material from the cars using the rollover machine, railcar derailment and/or damage to the rollover machine would occur. Repairs are costly and time consuming. As a result of these first winter problems, the dumping operation now has changed during the winter months. The solution to the problem used was the night prior to unloading, several cars are parked in a temporary shelter which is heated using portable space heaters, and a ramp has been constructed up to a platform on which sits a backhoe which excavates material from the cars. The rollover machine is not utilized during this period. The cars are also lined at the loading site with plastic sheets to prevent material from sticking to the car ribs.

Envirocare has recently expanded its ability to take a more diverse group of materials by obtaining a new disposal license. This may be utilized in the future by modification of contract in case the situation arises to allow disposal of material which has NORM as well as other hazardous waste components.

PERSONNEL PROTECTION

The work is little different in many respects than other work involving heavy equipment. This, coupled with the special hazards associated with radioactive materials and other possible contaminants, makes safety considerations of great importance. The contractor submitted an all-inclusive safety program specific to the work before transportation and disposal work began.

In addition to the typical personnel protection measures, any person working on the operable units must have physical examinations and attend the safety courses as required by the Superfund Amendment and Reauthorization Act (SARA) and Occupational Safety and Health Act (OSHA), including a baseline analysis for heavy metals. Also, certain site specific training and specialized radiological training is required to work on the properties being remediated.

External thermolyminescent dosimeters (TLDs) are required to be worn by all onsite workers. Geotech provides the TLD service. They are worn whenever anyone enters the restricted area and are left at an onsite trailer when leaving the restricted area. The TLDs never leave the site.

PUBLIC RELATIONS

Public relation aspects of the work are highly important and are primarily EPA's responsibility. When the subject of radioactive waste comes up, the public perception is that it is highly dangerous. The DRSS material averages about one-tenth of the value considered radioactive by DOT guidelines. Meetings with various groups help dispel fears and are very important to the timely completion of the work. Contacts have been made with local groups in the vicinity of the transfer station, and also with the cities and communities along the Colorado, Wyoming, and Utah routes for hauling of the materials. The fears subside, to a great extent, when the public is presented with the facts concerning the nature of the material, and when details of the Emergency Preparedness Plan are discussed.

SCHEDULING AND COORDINATION

The solicitation contained a master schedule for the work. This was intended to present only an indication of the sequence and duration of the work expected for the operable units involved. Waste may be hauled from as many as six operable units at one time, so a long-range, 30- to 60-day forecast schedule is necessary so there is some advance planning opportunity.

Communication and planning are the key elements to the success of this project. In order to ensure this process is maintained, Reclamation conducts biweekly meetings with the principal participants in the project. Representatives from Reclamation, EPA, Chem-Nuclear, Geotech, and the Colorado Department of Health are present at these coordination meetings. The meetings are informal and a free flow of information is encouraged. Usually, the quantity of material for loadout can only be predicted for a few days ahead and often changes daily. This presents formidable challenges to the transportation and disposal contractor to meet the demands of the loadout subcontractor. Flexibility and resourcefulness are required to prevent delays. The performance of the contractor to date has been exceptional in this regard.

Chem-Nuclear is required to handle a tremendous coordination and planning effort. It begins with estimating the quantity and using projected start dates and production rates obtained from Geotech and then sizing the hauling fleet, preparing containers, and scheduling the fleet. Chem-Nuclear also arranges for holding areas, scales, haul routes, and intermediate inspection points. For each loadout subcontract, at each loadout site, Chem-Nuclear must coordinate a loadout location consistent with Geotech's decontamination process, and develop a lid-handling facility. In several locations, Chem-Nuclear extended or refurbished existing rail lines to locations which could easily be serviced by the loadout subcontractor. Coordination on a daily basis is required from the railroad companies to efficiently order switches and, also, scales were installed at several sites which were utilized to more efficiently load the railcars. If no scale is available at the site, the amount of material loaded is estimated based on numbers of buckets and by experience for the particular type of material. If a car is too heavy to legally travel the rails or highway, the container is returned to the site to be downloaded at Chem-Nuclear's expense.

A value engineering (VE) study was performed in order to try to solve a difficult scheduling and engineering problem at the Duwald Steel site (operable unit No. II). This process was extraordinarily challenging because it included active participation between five divergent groups representing two contractors and three government agencies (Geotech, Chem-Nuclear, EPA, Reclamation, and the Colorado Department of Health). The basic problem was how to remediate the site while still allowing the owner to remain in business in a congested and dynamic scrap metal operation. Several

large buildings and major utilities on the site are founded on contaminated material and a large metal shredding machine integral to the owner's business must remain in service. This is the last DRSS operable unit and all of the DRSS disposal must be completed by the end of fiscal year 1992 (the end of the transportation and disposal contract). Attacking this problem, the VE team devoted a full week to identifying all problems and developing proposed solutions with an implementation plan. The plan included action items with due dates to ensure success of the process. The VE team was implemented and facilitated by Geotech personnel.

CONCLUSION

Reclamation has utilized their knowledge of construction contracting to provide the support needed by EPA in accomplishing the transportation and disposal phases of the DRSS work.

Reclamation's contractor, Chem-Nuclear, is successfully servicing DOE's remedial action contractors by providing the types of containers in the required quantities for loading. The transportation and disposal work is proceeding without significant problems. Reclamation's contracting and construction management capabilities make this agency very qualified to provide the services EPA needs to manage this type of work.

ACKNOWLEDGEMENT

Certain portions of background information for this paper were obtained from various EPA documents and fact sheets. These were of great help in developing this paper. The personnel whose work was used in some way include Timothy Rehder of EPA and Rich Grotzke and Jamie Macartney of Reclamation. Some information was also obtained from Jeff Stevens of Chem-Nuclear and Ron Carlson of Geotech.

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Cost Estimating Systems for Remedial Action Projects

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INTRODUCTION

Given the great uncertainties that surround design and construction activities for the remediation of hazardous, toxic, and radioactive waste (HTRW) sites, it stands to reason that cost estimates based on the same level of information will necessarily reflect this uncertainty. Proof of this can be seen in the extreme cases of cost escalation witnessed in a number of remediation projects as they move from design to completion. This fact presents a compelling need for cost estimating tools that are flexible enough to provide relatively accurate cost estimates based on the ever increasing amounts of information detailing site conditions, and yet simple enough to insure ease of use and rapid generation of results.

Toward this end, the United States Environmental Protection Agency (USEPA) and the United States Army Corps of Engineers (USACE) have been coordinating the development of independent, yet complementary, cost estimating computer programs. By insuring overall compatibility between the key aspects of software during the development process, users of these two cost estimating systems will enjoy the ability to generate estimates at various stages in the remedial action design and construction process by simply selecting an appropriate mix of software tools based of the level of design data that is available to them. Thanks to a series of informal meetings between the USEPA and USACE, there was early agreement on a set of common goals and objectives thus insuring that users would be able to combine the separate results from each model into a single unified solution. This paper provides a discussion of the two software tools that are currently under development, and will highlight their respective capabilities, both separately and in conjunction with the other.

BACKGROUND

Historically, remediation projects have experienced cost increases not seen in other construction projects. These cost increases can be attributed to a number of factors, chief among which is the incomplete characterization of the site and the extent of contamination. From the perspective of the cost engineer, this uncertainty will have an adverse impact the cost estimate. Cost estimates generated on the basis of unknown or uncertain information will always be subject to question. The end result is that many projects are grossly underestimated during early project stages, leading to a host of associated problems for site managers.

In July 1989, the USEPA and the USACE, each with strong interests in this area (and each with ongoing software development projects) initiated discussions to determine the feasibility of developing an integrated system of cost estimating tools for hazardous waste remediations based on software development already underway. The ultimate objective of the cooperative effort would be to insure that more accurate cost estimates are available for remediation work at early and intermediate stages of a remediation project where limited design information is available.

DISCUSSION

Cost estimates for HTRW remediation work generally reflect the type of costs that are associated with conventional construction projects. However, there are further considerations which complicate the generation of an HTRW cost estimate. For example, additional costs must be factored in for items ranging from special health and safety requirements to permitting activities.

Another problem arises from the selection, design, and construction of one or more treatment technologies, clearly a site specific item. The failure to completely characterize the site during the RI/FS process means that projects are bid by performance specification, where contractors are required to design and construct the required treatment technology system to fit the special needs of a site. This type of procurement is typically done with a lack of detailed design information. This means that a cost estimate for the treatment technology must be priced out by a process method rather than at the individual line item (unit cost) level. While the line item approach is capable of generating more accurate estimates than the process method, it also requires the type of detailed information that is often unavailable at early design stages. As a site becomes better characterized over time, it may be desireable to revise estimates, substituting line item estimates where possible. The focus of the USEPA and USACE collaboration is to develop cost estimating software tools that will integrate the estimation of both system costs and detailed line item costs.

The USEPA's system, RACES (Remedial Action Cost Estimating System) is a treatment technology-based HTRW cost estimating system that is currently under development by the Risk Reduction Engineering Laboratory. RACES asks the user to select a specific treatment technology, to input known and assumed site characteristics, and to assign general cost factors. The end product is a comprehensive (and easily modified) estimate of capital and operating costs, both on a life cycle and a present value basis. While the RACES system has been developed for use in the preliminary and intermediated design phase, it is also suitable for budget estimating.

The system relies upon two types of cost data to generate it's estimates: (1) unit (line item) costs, and (2) cost estimating relationships (CER's). Unit costs are comprised of specific discrete components or items of work that are typically found in the construction industry. These individual unit costs are collected into assemblies and then reported to the user in that fashion. Presently, RACES has compiled unit costs based on some 600 detailed tasks originally drawn from the R.S. Means and Richardson Engineering databases (and used by permission of the respective organizations). As part of the coordination with the USACE, future versions of RACES will rely on unit costs taken from the Corps of Engineers own Unit Price Book (described below).

Conversely, CER's are algebraic equations used to estimate costs based on relevant variables. CER's are primarily used to estimate costs of complete treatment systems and subsystems over a range of capacities. The CER's in RACES are derived from a number of sources including published cost engineering reports, expert opinion, and independent cost engineering analyses. Each CER will be independently validated before release. The use of this approach is most appropriate when it is impractical to develop a unit cost item for every component of a system covering every possible size.

The RACES system is focused on two general classifications of HTRW technologies: (1) control technologies (i.e., slurry walls, subsurface drains, etc.), and (2) treatment technologies (i.e., incineration, air stripping, etc.) Within the RACES system, unit costs are used to generate costs for control technologies. Treatment technology costs are generally arrived at through the use of CER's.

The USACE system, M-CACES (Micro-Computer Aided Cost Engineering System) is, in contrast, a "bottoms-up" estimating tool. It is utilized primarily for development of cost estimates for which detailed design information is available. M-CACES is a proven system and has been used by the Corps to estimate the cost of both military construction and civil works projects. It is the HTRW portion of M-CACES that is currently under development by the Corps.

Estimates derived from M-CACES reflect labor, equipment, and material costs taken from the USACE's Unit Price Book (UPB) database, which is maintained and updated regularly by the Corps. At the present time, the UPB database contains more than 20,000 individual line items covering all aspects of construction work. To meet the needs of the HTRW portion of M-CACES, the UPB is being updated to include specific line items relating to HTRW, mixed, and radioactive wastes. At the present time, over 1,700 HTRW line items have been developed for the UPB. An additional 900 HTRW line items, and up to 1,000 mixed and radioactive waste line items, are scheduled for development during 1991.

The interest in an interface between RACES and M-CACES arose from the fact that RACES provides the only known tool (partial or completed) for predicting HTRW treatment technology costs. As mentioned earlier, in order to provide performance specification contract estimates, the Corps of Engineers must necessarily generate estimates without formal design documents. RACES can provide treatment technology cost forecasts which the Corps can supplement with the standard line item estimates available through M-CACES. Since the RACES generated treatment technology cost estimates are based on CER's (without the support of material and labor details) they will be represented in M-CACES as elemental costs, unsupported by line item detail. From a software perspective, any treatment technology estimates are placed in an output file from RACES and then imported into M-CACES.

Since the initial meetings in early 1990, collaboration between the USEPA and USACE has extended beyond the confines of computers and software to encompass the broad range of cost engineering issues confronting practitioners in this field. A case in point stems from the joint concern over a lack of standard database to collect and categorize the costs from completed remediation projects. The existence of such a database is a critical component in verifying the accuracy of any cost estimating system. As a result, a side effort was undertaken to develop a common database structure for use by all government agencies.

The first step in this process was the development of a standard HTRW work breakdown structure upon which a code of accounts would be based; a work breakdown structure is a hierarchical breakdown of the work into a numbered structure, organized in a logical manner. Toward this end, representatives from the USEPA, USACE, Navy, and DOE met in January of 1991 to develop a draft HTRW Code of Accounts. After breaking the work into four major phases (assessment, engineering/design, construction/remediation, and construction management), the group focused it's efforts in two to the four phases, the assessment phase and construction/remediation phase. Draft copies of the Codes of Accounts for these two areas are being reviewed within the various agencies with a goal to issue a final version by September 1991. Issues yet to be resolved include the establishment of collection procedures for cost data and management of such a database.

CONCLUSION

Previously, neither agency has had a complete software tool for use in the preparation of HTRW cost estimates. When work on RACES and the HTRW portion of M-CACES is finally completed, the two systems will be able to provide cost engineers with a comprehensive estimation tool that allows the generation of estimates at various levels of site detail. The collaboration between cost engineers at the USEPA and the USACE continues. Representatives of other Federal agencies, such as the Department of Energy, are also providing input to this effort based on their own remediation needs. It is clear that these informal inter-agency efforts will continue into the future, and may someday lead to larger and more comprehensive estimating systems.

HTW Construction Documentation Report: A Necessary Element in a Successful Remediation

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INTRODUCTION

To most people a hazardous and toxic waste (HTW) remedial action consists of two elements, design that culminates in plans and specifications, and construction that implements the design. However, a third element, documentation and evaluation of the completed remedial action as it was actually constructed is also needed. Existing HTW guidance provides for a remedial action report, but the focus of this guidance is to provide certification that the remedy was performed in general accordance with the design and is operational and functional. Existing guidance does not address the type of data or information useful to evaluate the long term effectiveness and performance of the remedy or improve future designs. A HTW Construction Documentation Report, which would document construction activities and evaluate construction data, is an essential element in a successful remediation.

BACKGROUND

POST REMEDIAL ACTION GUIDANCE:

US Environmental Protection Agency. Existing HTW guidance on post remedial action reports on Superfund projects is contained in US EPA publication, "Superfund Remedial Design And Remedial Action Guidance". A remedial action (RA) report is to be prepared by the agency that has primary responsibility for construction inspection. It is to contain the following elements:

- "Brief description of outstanding construction items from the prefinal inspection and an indication that the items were resolved
- Synopsis of the work defined in the SOW and certification that this work was performed
- Explanation of any modifications to work in the SOW and why these were necessary for the project
- Certification that the remedy is operational and functional
- Documentation necessary to support deletion of the site from the NPL.

For a responsible party remedial action, the document of settlement may specify different final inspection/ certification conditions."

US Army Corps of Engineers. The Corps of Engineers included post remedial action reporting guidance in the "Superfund Management Guide" which provides Corps personnel with general guidance on management of EPA Superfund work assignments. It states that the Corps

"will forward to the EPA Region all pertinent documents once the project is completed. Documents include reports sufficient to develop a chronological record of site activities, e.g., contractor daily reports, change orders, problems and solutions regarding compliance with environmental and contractual requirements, laboratory and monitoring data, etc. An Abstract of these data should also be sent to the Design Division and HQUSACE (DAEN-ENE-B), for information purposes only. For example, include:

(a) synopsis of work described in the contract and certification that this work was performed;

(b) explanation of any modifications to original work scope and reasons they were necessary for the project;

(c) listing of the criteria, established before the remedial action was initiated, for judging the functioning of the remedy and explanation of any modification to these criteria; and

(d) results of site monitoring, indicating that the remedy meets the performance criteria."

To date, post remedial action reports have not been prepared for all construction projects completed. Distribution of completed reports has been limited. In some cases, the designers have not been provided with the reports. Reports prepared to date have included varying levels of detail. A report prepared for a landfill closure provided photographs, drawings, lessons learned, and some details about actual construction. A report prepared for a total containment remedy contained little information or data from actual construction activities. Although both reports provide the certification that the constructed remedy is operational and functional, they contain little information to provide a basis for evaluating the long term effectiveness and performance of the remedy or to provide information useful to designers of similar components.

DOCUMENTATION AND EVALUATION GUIDANCE:

Even though existing post remedial action guidance does not address documentation and evaluation, guidance does exist that can be readily adapted to remedial actions.

Landfill Document Report. Specific guidance for a construction documentation report that would be useful in evaluating the long term performance and provide for technology transfer is presented in EPA's Technical Resource Document on Design, Construction, and Evaluation of Clay Liners for Waste Management Facilities. Documentation is addressed as the fifth element of a construction quality assurance plan. Major elements of the construction documentation report are listed as engineering plans, engineering cross-sections, comprehensive narrative, series of 35-mm color prints, and construction certification. Wisconsin Department of Natural Resources regulations include a complete chapter on landfill construction documentation which expands on the elements presented in EPA's Technical Resource Document.

US EPA's SITE Program. US EPA's Superfund Innovative Technology Evaluation (SITE) program provides an interesting parallel to remedial actions. At the completion of each demonstration project, a technical report documenting performance data resulting from the demonstration is required. The "Demonstration Report" includes testing, procedures, data collected and QA/QC conducted. It summarizes the results in terms of performance (effectiveness and reliability) and cost. The report is used as a technology transfer tool.

US Army Corps of Engineers. The Corps of Engineers, perhaps because of its unique role in designing, constructing, operating and maintaining major civil works projects, i.e., dams, locks, etc., has long recognized the need for and the value of documenting construction activities and evaluating the performance of completed civil works construction projects. Two separate Engineering Regulations (ERs) govern these activities. The first regulation is "CONSTRUCTION FOUNDATION REPORTS." The purpose of this regulation is to require the preparation of

> "as-built foundation reports for all major and all unique civil works and military construction projects. Major construction projects are those that fall in the category of multimillion dollar, multipurpose projects, whereas unique construction projects are those, regardless of size, on which difficult, critical or unusual foundation problems were encountered, or for which unique design and/or construction procedures were developed."

It states the following reason for preparing foundation reports and their intended uses:

> "Properly prepared foundation reports insure the preservation for future use of complete records of foundation conditions encountered during construction and of methods used to adapt structures to these conditions. During construction, voluminous records often are maintained that are filed on completion of the project without regard to possible future usefulness. When an occasion arises at some later date requiring reference to these records, considerable time is consumed and difficulty encountered in finding all the needed information. Such information is readily available if it is assembled in a concise foundation report at the time of construction.
>
> The most important uses to which foundation reports are put are (1) in planning additional foundation treatment should the need arise after project completion, (2) in evaluating the cause of stress, deformation or failure of a structure, and in planning remedial action should failure or partial failure of a structure occur as a result of foundation deficiencies, (3) for guidance in planning foundation explorations and in anticipating foundation problems for future comparable construction projects, (4) as an information base in determining the validity of claims made by construction contractors in connection with difficulties arising from alleged foundation conditions or from alleged changed conditions, and (5) as part of the permanent collection of project engineering data..."

The second regulation is "EMBANKMENT CRITERIA AND PERFORMANCE REPORT." The purpose of this regulation is to require the "preparation of an as-built embankment report that summarizes the design criteria and embankment performance for all earth and earth-rockfill construction projects." It states the following reasons for preparing Embankment Criteria and Performance Reports:

> "A properly prepared report will provide a summary record of significant design data, design assumptions, design computations, specification requirements, construction equipment, construction procedures, construction experience, field control and record control test data, and embankment performance as monitored by instrumentation during construction and during initial lake filling. The report will provide in one volume the significant information needed by engineers to (1) familiarize themselves with the project, (2) re-evaluate the embankment in the event unsatisfactory performance occurs, and (3) provide guidance for designing comparable future projects."

Many similarities exist between civil works projects and remedial actions. A civil works project can have an expected design life in excess of 100 years. If complete removal and destruction of contamination is not achieved during a remedial action, contamination may exist indefinitely. Failure

of a civil works project as well as a remedial action may endanger the public. Thus, the documentation and evaluation practices vital to the success of civil works projects are appropriate for HTW remedial action projects.

DISCUSSION

The value of documentation is highlighted by the fact that construction activities are seldom exactly as assumed during design. The main factors in these differences are contractors and site conditions. No two construction contractors operate in the same manner. Personnel, equipment, and resources vary. Site and subsurface conditions are difficult to assess completely and accurately during investigation and design. The effectiveness and perfomance of a remedy can not be evaluated without actual construction details and data. Future design can not benefit from past construction activities without a method of technology transfer. The importance of feedback from construction activities is enormous.

In order to accomplish this, good documentation and evaluation practices must be implemented. These practices will result in an HTW Construction Documentation Report. A properly prepared report will record and preserve construction records, conditions, and activities in a readily accessible form and evaluate construction data. The report may be used by various or- ganizations to provide the following:

(1) Record of construction activities. Historical documentation will be available as to quantities excavated, cleanup levels, materials or equipment used. This is particularly important in rapidly advancing areas of innovative technology and to provide factual data for potential litigation.

(2) Field data applicable to design of future operable units. Many times, construction activities of one operable unit provide valuable design information for another operable unit on a site. Information may include dewatering quantities, additional characteristics of subsurface conditions, and borrow material used.

(3) Information required for long term performance monitoring and site maintenance. Long term performance monitoring and site maintenance are required at HTW sites where the remedial action results in any hazardous substance, pollutants, or contaminants remaining on the site. This monitoring may continue for a period of 30 years or more. Good data on construction activities will identify areas that need closer attention during long term maintenance. Problems occurring during construction may identify areas needing particular monitoring to ensure adequate performance of the remedial action.

(4) Baseline information for design of repair/modifications in case of failure. In the event of failure of any portion of the remedial action, the construction documentation report will provide a starting point for evaluation of the nature of the failure. Cause of the failure, design and/or construction related, is important in the design of the repair/modification.

(5) Basis for SARA mandated review/evaluation. SARA (Superfund Amendments and Reauthorization Act of 1986) requires "review of such remedial action no less often than each 5 years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial ac- tion being implemented." SARA section 121.(c)

(6) Account of lessons learned. The complete account of the lessons learned, supported by data, is also an important part of the construction documentation report.

The HTW Construction Documentation Report, in conjunction with the Design Analysis, Site Maintenance Plan, Construction Specifications, and As-built Drawings will form the permanent collection of project engineering data.

Documentation and evaluation practices are the responsibility of both the construction quality assurance (CQA) staff and the designers. Successful remediation is a team effort. The HTW construction documentation reports should be prepared by persons who have firsthand knowledge of the project design and construction. Where possible, the authors should be the designers and the CQA staff responsible for the detailed work on the project. The CQA staff would be responsible for compiling field data/activities and lessons learned. Where possible and considered efficient, data collection can be included in the construction contract. Based on the data and their CQA experiences, the CQA staff would make appropriate recommendations for future monitoring, design or construction activities. The designers would be responsible for evaluation of the data. Recommendations that would affect future design work at the site or affect the operation and maintenance of the site should be a joint effort of the CQA staff and the designers. Reports should be finalized within six months after the project is substantially complete.

Costs for preparation and reproduction of a HTW construction documentation report should average about 1 percent of the total construction costs for projects under $10,000,000 and 0.5 percent for projects exceeding $10,000,000.

CONCLUSIONS

Timely and comprehensive HTW Construction Documentation Reports are an essential element in assuring the successful long term effectiveness and performance of a remediation and will provide technology transfer to improve future designs. Rapid implementation to prevent further loss of valuable information is critical. Support from US EPA, designers, and construction CQA staff is vital.

DISCLAIMER

Missouri River Division, HTW Design Center for the Corps of Engineers fully supports the need for HTW Construction Documentation Reports and continues to work towards its implementation.

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CHANGE ORDERS CAN RUIN YOUR DAY: AN ANALYSIS OF CONSTRUCTION CHANGE ORDERS IN THE REGION 6 SUPERFUND PROGRAM

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I. INTRODUCTION

One of the problems of living in an imperfect world is spending a lot of time and money undoing past mistakes, resolving unexpected difficulties, or adjusting one's priorities based on new information. While this may sound like the beginning of a lofty sermon, these basic concepts form the basis for the very down-to-earth changes that occur on every construction project in the form of change orders. The likelihood that some changes will be required in the course of any construction project, whether it is the assembly of a stealth fighter or the addition of a family room, is very high.

While the term "change order" has historically caused Region 6 management to wince, the Superfund design and construction program addresses the treatment of historical contamination which has typically not been well characterized, such that change orders are almost inevitable. However, while some change orders are unavoidable, others can be averted, or their negative impacts can be minimized. Remedial Project Managers (RPMs), in conjunction with their management, EPA Headquarters, the State, and the designers, can improve the Remedial Design process to minimize those change orders which can be avoided and adequately prepare for those which cannot.

This paper attempts to provide a snap shot description of the types of change orders encountered in Superfund construction projects in Region 6. Nine completed projects and one on-going project which were Federally-funded and conducted by either the State or EPA were analyzed as a basis for the conclusions in this paper. The

Table I. Analysis of cost overruns based on total Remedial Action costs.

SITE	CHANGE ORDERS ($1,000)	FINAL RA COST ($1,000)	COST INCREASE
Geneva	$4,386	$20,521	27%
Old Inger*	$2,827	$7,866	56%
Highlands	$1,397	$5,419	35%
Bio-Ecology	$1,578	$5,317	41%
PetroChem	$27	$1,717	2%
Crystal City	$147	$1,239	13%
Triangle	($27)	$480	-5%
Odessa 2	($45)	$344	-12%
Odessa 1	($11)	$159	-16%
United Creosoting	$37	$133	38%

*Data obtained from pending change order claims. Project is ongoing, and final costs not available.

construction activities at these sites were conducted between the years 1987 and 1991, with final construction costs ranging from about $133,000 to $20.5 million.

Table I shows that, in general, the more expensive projects experienced more significant overruns than the smaller projects did. The exception to this trend was the United Creosoting demolition, which was the smallest project, but registered the third highest percent overrun. The possible reasons for this are discussed in Section II.

II. ANALYSIS OF CHANGE ORDERS IN REGION 6

A. Evaluation of Change Orders Based on Remedy Type

The activities conducted at the sites included building demolition, road construction, waste vault construction, water supply system installation, landfarming, soil aeration, slurry wall construction, and excavation and off-site disposal. Since most of the projects for which construction activities are complete resulted from relatively "old" Superfund Records of Decision (pre-SARA RODs), the technologies represented are more conventional construction activities. Therefore, little information on the construction of newer innovative technologies such as soil washing or "high tech" remedies such as onsite incineration is available in the Region to date. Table II shows the types of remedies selected.

Table II. Relationship of remedy type to RA cost overruns.

SITE	ROD	REMEDY TYPE	COST INCREASE
Old Inger	pre-SARA	Excavate/landfarm	56%
Bio-Ecology	pre-SARA	Excavate/landfill	41%
United Creosote	pre-SARA	Clean/demolition	38%
Highlands	pre-SARA	Excavate/off-site	35%
Geneva	pre-SARA	Excavate/off-site	27%
Crystal City	post-SARA	Excavate/landfill	13%
PetroChem	post-SARA	Clean/Road	2%
Triangle	pre-SARA	In-situ aeration	-5%
Odessa 2	pre-SARA	Clean/water supply	-12%
Odessa 1	pre-SARA	Clean/water supply	-16%

This study showed that certain types of construction are more prone to change orders than others. In particular, those projects which involve the excavation, removal, and handling of hazardous wastes (contaminated soil, sludges, lagoons) will generally experience significant changes due to additional waste quantities and unknown site conditions. However, those sites which involve "clean" construction activities such as road construction and water supply system installation can be executed with few changes, since the design of such projects can be well specified. Figure 1 illustrates this point, showing that most sites with remedies

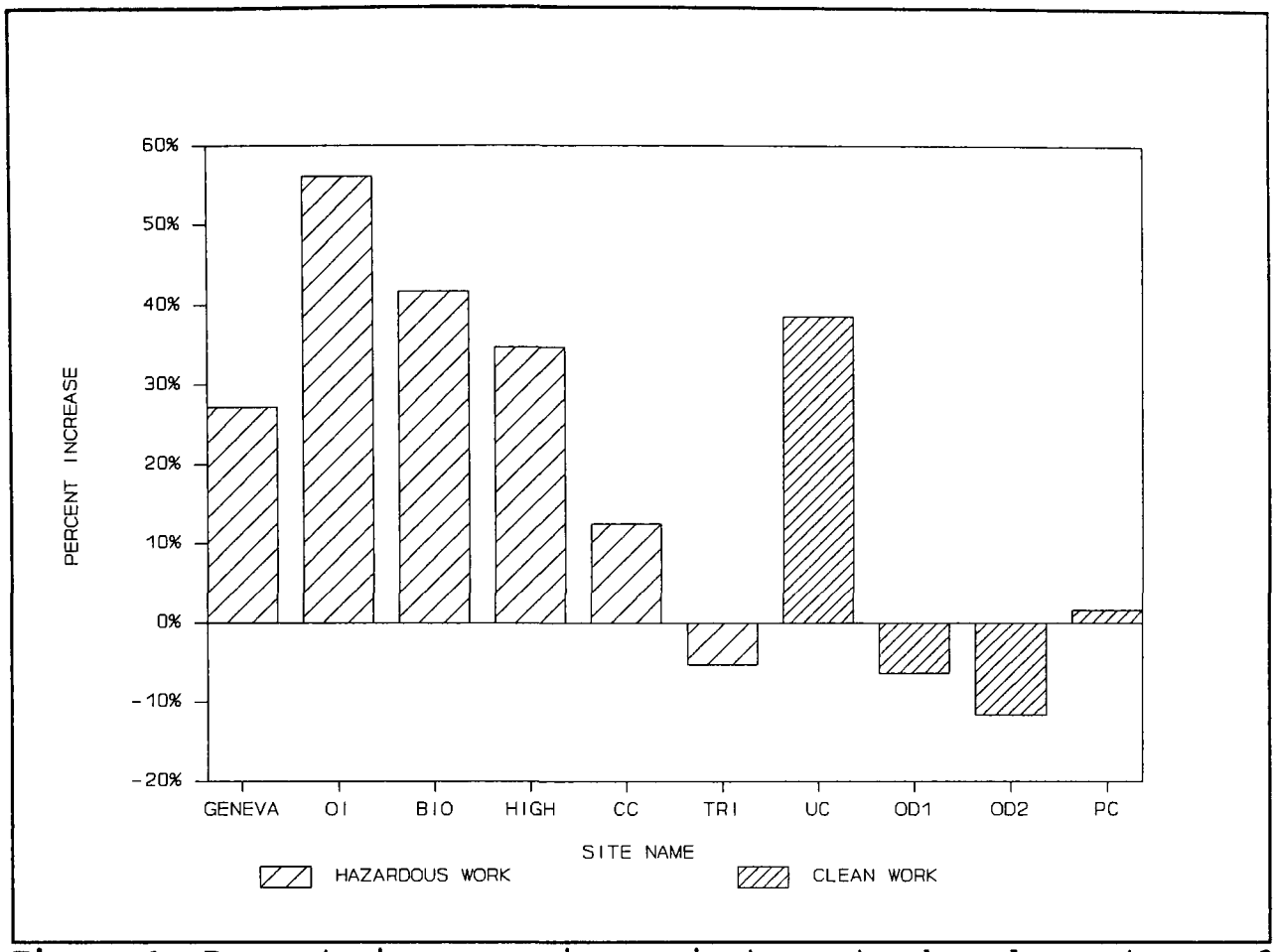

Figure 1. Percent increase in project costs based on type of remedy.

involving hazardous work experienced significant overruns (Geneva, Highlands, Bio-Ecology, Old Inger), while those projects involving "clean" construction had smaller overruns or were actually completed under budget (Petro-Chem, Odessa 1 & 2).

The exceptions to these general observations included the United Creosoting and Triangle Chemical sites. At United Creosoting, while the construction activities at the site were primarily non-hazardous, a significant increase in price resulted from encountering hazardous wastes in the form of asbestos-backed floor tiles in the homes. At the Triangle site, additional contaminated soils were encountered, but the quantity of trash and debris to be removed from the site was over-estimated in the bid package, resulting in a net decrease in project costs.

B. Relationship of RI/FS Spending to Remedial Action Overruns

Common sense would lead one to the conclusion that a poorly characterized site would likely experience significant overruns in contract price due to excess waste quantities and differing site conditions. In order to confirm this hypothesis, the costs

Table III. Comparison of RI/FS spending to RA cost overruns.

SITE	RI/FS COSTS (THOUSANDS)	RATIO OF RI/FS TO RA COSTS	RA COST INCREASE
Old Inger	$348	4.4%	56%
Bio-Ecology	$357	6.7%	41%
United Creosote*	--	--	38%
Highlands	$355	6.6%	35%
Geneva	$1,065	5.2%	27%
Crystal City	$652	53.1%	13%
PetroChem	$329	19.2%	2%
Triangle	$175	36.5%	-5%
Odessa 2 AWS	$181	52.6%	-12%
Odessa 1 AWS	$161	101.0%	-16%

*Available RI/FS data covers entire site while RA costs are associated only with interim remedy.

associated with the Remedial Investigation and Feasibility Study (RI/FS) for each site were compared to the percent overrun experienced at the site. Instead of comparing RI/FS spending directly with RA cost overruns, a ratio of RI/FS costs to total RA costs was established to account for the relative size of the projects, and this ratio (percentage) was then compared to RA cost overruns.

As Table III demonstrates, those projects with a very low RI/FS to RA ratio (less than 7%) showed significant cost increases, while those projects with a higher ratio showed smaller RA cost increases. If RI/FS spending is taken as a reasonable indicator of the degree of characterization of the site, the data confirms that a poorly characterized site (represented as a site with an RI/FS to RA spending ratio of less than 7%) will experience significant overruns, while sites which are better characterized (RI/FS to RA spending ratio of above around 20%) will generally experience lower overrun percentages . The United Creosoting site was excluded from this analysis, since the costs associated with the RI/FS for the interim remedy (house demolition) could not be segregated from the total RI/FS costs for the entire site.

III. INCREASES IN CONTRACT PRICE

For this study, the change orders in Region 6 were segregated into six cost increase categories and one cost decrease category. The cost increase categories include excess waste quantities, force majeure, administrative delays, differing site conditions, scope changes, and pollution liability insurance. Project cost decreases which could not be factored into the categories above were classified as scope reductions.

The increases in project costs after issuance of a contract can be classified by category into avoidable and unavoidable increases in

contract price. Those change orders resulting from things within the control of the Government or the contractor, such as inadequate site characterization, administrative difficulties, and changing Government needs or priorities, were classified as "avoidable". However, change orders caused by acts of God or third parties were classified as "unavoidable".

A. Avoidable Increases in Contract Price

Those categories of change orders which have been classified as avoidable increases in contract price include excess waste quantities, administrative delays, differing site conditions, and scope changes. In most cases, the savings associated with the elimination of these change orders result from competitive prices (through from the bidding process) and reduction of unnecessary project administrative effort.

While these types of change orders could generally be reduced or avoided, elimination of the change order may not result in as significant of a reduction in contract price as might be expected. This is due to the fact that the overall scope of a Superfund project is "fixed" by the performance standards established in the ROD, and the Government will most likely pay for remediation of all material exceeding these standards, whether or not the full amount is known at contract award. For example, though EPA may not be aware of all of the materials which exceed the cleanup criteria, all of these wastes must be addressed to comply with the ROD.

1. Excess Waste Quantities

The largest single contributor to increased costs in Superfund construction, and probably the most difficult to address, is excess waste quantities. As shown in Figure 2, the dollar amount of excess quantity change orders represents approximately 70 percent of all change orders processed in Region 6.

The primary reason that excess waste quantities are frequently encountered at Superfund sites is that the extent of contamination is usually inadequately defined. In the past, EPA's field efforts during the Remedial Investigation (RI) have served as the only information about waste quantities upon which the design is based. The Remedial Investigation and Feasibility Study is usually conducted under an eighteen-month schedule leading up to the publication of EPA's Record of Decision for the site. Typically, little time has been taken for any supplemental field work to answer questions raised but not answered during the RI.

As indicated in Section II, the thoroughness of the RI/FS, among other things, appears to have a significant impact on the percentage overrun the project will experience. However, the fact that the data collected during the RI is insufficient can be addressed by additional sampling and testing during the Remedial Design. While the target duration for an RD is currently 18 months, RPMs should evaluate the feasibility of such a schedule based on the quality of the data available for the site.

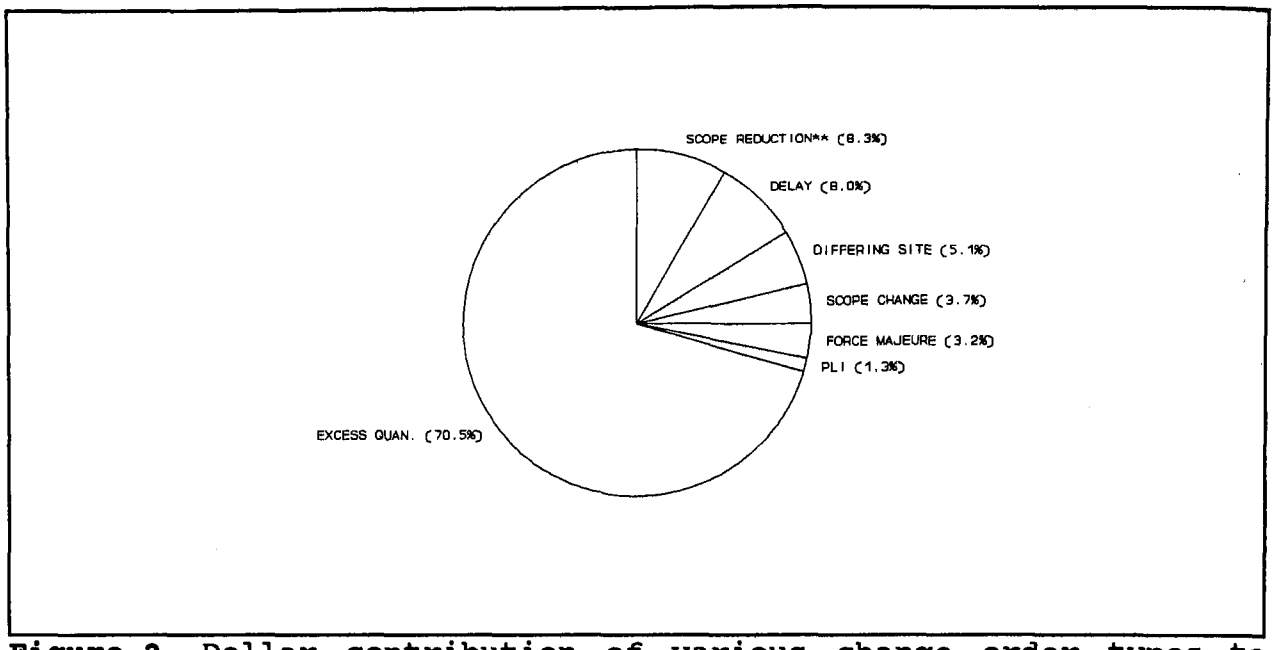

Figure 2. Dollar contribution of various change order types to overall cost of change orders in Region 6.

Additional field work should be incorporated into the design if better characterization of the site is necessary. RPMs and designers should also account for the age of the RI data when evaluating whether additional field work is warranted.

2. Administrative Delays

Administrative delays at Superfund sites have proved to be a recurring problem in Region 6. These delays may result from a number of conditions, including access problems, difficulties in obtaining permits, non-compliance of an off-site facility, and contractual or legal problems. These types of delays were encountered at four of the ten Region 6 sites analyzed.

At the Crystal City site, administrative delays represented 51 percent of the overrun for the project. After EPA's selection of the remedy, the city of Crystal City, owners of the site, had expressed strong dissatisfaction with remedy selected by EPA in the ROD. While access had been obtained from the city for the conduct of the RI/FS and the remedy, the Remedial Action contractor arrived at the site with his equipment to find the gates padlocked and patrolled by the local authorities. In this case, verifying that access was in fact available prior to issuing a notice to proceed may have reduced or eliminated these delay costs. EPA is now requiring states which conduct remedial actions under cooperative agreements to provide assurances of access and a completed design package before awarding RA funds.

3. Differing Site Conditions

Conditions at a site which differ significantly from what is represented in the construction drawings and specifications are considered differing site conditions. This type of change may result from buried debris or concrete structures not shown on the plans, additional waste of a different character or in a different location than expected, or inadequate onsite materials or facilities which were specified for use by the design.

The United Creosoting site experienced a 23.5 percent increase in contract price due to a differing site condition. This project involved the demolition of six Government owned homes which were built over old creosote waste pits. Upon initiation of the demolition activities, the contractor discovered that the floor tiles in the homes were backed with an asbestos material. This required special handling and disposal which had not been anticipated in the original design.

The reason for encountering differing site conditions is similar to that associated with excess waste quantities: inadequate or incomplete information about the site. Although some conditions cannot even be conceived of during the design, others should be expected as a matter of course for Superfund work. Designers should visit the site at a minimum to evaluate the current site conditions, and RPMs should provide time and money in their design schedule and budget to do additional field investigations based on their own evaluation and the designer's recommendations.

4. Scope Changes

It is almost inevitable that during the course of a construction project, the owner needs additional work done related to the principal construction effort which was not part of the original contract scope of work. For example, EPA may request additional sampling and analysis, surveying, or design changes which are not specified in the contract.

At the Petro-Chemical site, additional surveying was requested by EPA to further define surface drainage patterns. Based on this data, the drainage design was revised to correspond to actual field conditions. This change of about $18,000 proved to be one of the most significant change orders for the site.

Some scope changes may result from oversights in the original design. For example, the design for the Geneva Industries site omitted the installation of pressure relief well casings through the RCRA cap as specified in the ROD. Additionally, the locations of the casings for the ground water remediation pumping wells were changed. These changes resulted from a decision during the design to delay implementation of the ground water remedy design and construction until later. As a result, some of the activities associated with the ground water remediation (such as well placement) which needed to be addressed during the source control construction were overlooked. While this change order was small

($3,500) compared to others for this site, such changes can be avoided.

B. Unavoidable Increases in Contract Price

1. Force Majeure

Force majeure change orders result from events or third party actions which are not within the control of the contractor or the owner (EPA or the state). Such events include unusual or extreme weather conditions and actions of third parties. In Region 6, two of the ten sites studied experienced force majeure events for which change orders have been processed. By nature, these events can neither be anticipated nor avoided. The project manager must rely on contingency planning and budgets to address such problems.

For the Geneva project, the off-site landfill facility selected by the RA contractor to receive wastes from the site was located in Alabama. As the contract-scheduled date for shipment of wastes from the site approached, the Alabama Attorney General filed suit against EPA requesting an injunction to stop implementation of the remedy selected in the ROD. The complaint stated that, as an "affected state", Alabama had not been given the opportunity to comment on the selected remedy. The request for injunction was granted by a Federal District Court, and the project was delayed for nine months while EPA fought (and succeeded) to overturn the ruling. The costs associated with this delay exceeded $680,000.

2. Pollution Liability Insurance

About 1.3 percent of the change order dollars spent in Region 6 have resulted from EPA's payment of the contractor's pollution liability insurance premiums. This accounted for about 23.5 percent of the changes at the Crystal City site and about 5 percent at Old Inger. In order to improve competition by increasing the field of contractors eligible to bid on Superfund construction projects, the Superfund Amendments and Reauthorization Act (SARA) provided procedures by which EPA could pay for pollution liability insurance premiums if contractors could not obtain the insurance at a fair and reasonable price.

In the case of Crystal City, EPA elected to pay for the contractor's coverage in the form of a change order. However, at other sites, these premiums have been paid in a separate procurement action. At Old Inger, the pollution liability insurance change order paid for an extension of the contractor-purchased coverage because the contract duration was significantly increased by the excavation and treatment of additional waste quantities.

IV. Decreases in Contract Price

In many cases, decreases in contract price are warranted because of scope reductions and material underruns. The aggregate of these reductions in contract price may prove to be significant. Overall,

scope reduction change orders represented about 2 percent of the total change order dollars changing hands on Region 6 Superfund construction projects. At the two Odessa sites, only one change order was processed for each site at the end of the project to adjust for final installed quantities.

These change orders may result from contingency bid items (such as access road repair) which are not necessary, unit price bid items for materials which are not needed, or improvements or adjustments to the specific work which result in a lower cost to the Government.

Some problems may be associated with significant decreases in contract price. Typically, if a unit price bid item underruns by more than 15 percent, the contractor is entitled to an adjustment in the unit price to reflect any per unit cost increases he may incur as a result of handling a lesser quantity. Additionally, major reductions in scope may cut into a contractor's profit, resulting in potential claims.

V. MINIMIZING CHANGE ORDERS AND CONTINGENCY PLANNING

Minimizing the change orders in a construction project can save the Government money in a number of ways:

-all the work incorporated in the original solicitation benefits from the scrutiny of a competitive procurement,

-the negotiated price of a change order, though reasonable, may not be the cheapest way to get the job done,

-the cost of additional staff time and travel associated with negotiating change orders can be avoided, and

-costly extensions to the project schedule which have the domino effect on other portions of the project can be avoided.

There are a number of things an RPM can do to minimize the change orders he may experience during the remedial action. First, it is essential that, prior to initiating the remedial design, he thoroughly review (and requires the designer to review) the available data for the site, including the Remedial Investigation, Feasibility Study, treatability study results, after action reports from any removals conducted at the site, and supplemental field work data. The RPM should ask questions such as the following:

-How well is the depth of contamination defined?
-Do we know what is in all the tanks onsite?
-What wastes were removed or consolidated during the removals?
-Were there any buildings onsite which are no longer there? Have their foundations been accounted for?

-Did the treatability studies provide sufficient design parameters for a treatment system?
-Are there any easements or restrictions on the site property which may impact the construction.

Second, RPMs and their management should not hesitate to conduct additional field investigations and pilot tests if the current data is sketchy. This type of field effort can be very beneficial, since it can be tailored to specifically address the data gaps identified during the data analysis. The time and money spent to better characterize the site is almost always less than the resources expended in change orders resulting from poorly defined waste quantities and site conditions.

Finally, if the high degree of uncertainty concerning the conditions at the site cannot be avoided, the RPM should evaluate contracting mechanisms which minimize the impacts of this uncertainty to both EPA (or the State) and the contractor. For example, the contract could establish a minimum quantity of waste which is anticipated and solicit a unit price for additional quantities above this amount.

In all cases, EPA should establish a contingency fund in the cooperative agreement, interagency agreement, or work assignment for unexpected and unavoidable changes. EPA's Superfund Remedial Design and Remedial Action Guidance, June 1986, recommends establishing a change order contingency of between 8 and 10 percent, depending upon the total cost of the project.

However, based on the experience of Region 6, the overruns experienced at a site relate to the complexity of the remedy, uncertainties concerning the quantity of wastes, and the degree to which wastes must be handled. For those sites involving excavation and handling of contaminated soils or sludges with a high degree of uncertainty concerning waste quantities, higher contingencies are warranted. The four Region 6 sites which fall into this category (Geneva, Old Inter, Highlands, and Bio-Ecology) had

Table IV. Suggested contingency fund limits as a percentage of estimated construction cost.

	CONTINGENCY FOR GIVEN LEVEL OF UNCERTAINTY		
REMEDY TYPE	LOW	MEDIUM	HIGH
NON-HAZARDOUS	5%	10%	N/A
SIMPLE HAZARDOUS	15%	20%	30%
COMPLEX HAZARDOUS	25%	35%	45%

overruns ranging from 27 percent to 56 percent. Conversely, those sites requiring conventional construction activities with little or no waste handling will be well served by an 8 to 10 percent contingency. Table IV provides a suggested guide for establishing contingency limits based on these factors.

V. Conclusions

While it would be nice for Remedial Project Managers to develop superhuman x-ray vision to determine what's under the ground and in the ground water, EPA can minimize the uncertainty associated with Superfund remedial actions using very human methods. Each player in the design and construction process has a part in improving the design information for the site and producing a reasonably accurate design. Designers should take responsibility for identifying and informing EPA and the State of data gaps and design uncertainties. Regional management and Headquarters should readjust expectations concerning design schedules to allow time for improving the design data picture through additional field work and careful design reviews. Finally, the RPM should be attentive to problem areas prone to change orders, uncertainties in waste quantities, and faulty or inadequate designs, and he should establish appropriate contingency budgets and schedules based on the data uncertainties and project complexities.

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Remedial Action Bids and Cost Estimates

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INTRODUCTION

Cost estimates for Superfund Remedial Actions (RA) are prepared during the Feasibility Study (FS) for the ROD and during the Remedial Design (RD) by the design engineer. According to EPA Guidance, these two cost estimates are targeted to fall within +50/-30 percent and +15/-5 percent, respectively, of the actual cost of the RA. This paper compares the ROD estimates and the engineer's estimates to the bids and actual costs of RAs at 24 federal-lead Superfund sites.

BACKGROUND

The Hazardous Site Control Division of EPA, in conjunction with CH2M HILL, has developed a database of bids that were received for RAs at federal-lead Superfund sites. For each site, the database contains a description of the RA and technologies used in the remediation. It also contains, on a line item basis, the ROD and engineer's cost estimates and the contractors bids. If the RA has been completed, the dollar value of any change orders is also presented. The database currently contains entries for 52 sites and actual completion costs for 25 of the sites. Table 1 contains a summary of the cost information in the database. Table 2 lists the technologies used for the RAs in the database.

For this study, the differences between the ROD estimate, the engineers' estimate, the contractors' bids, and the final cost of the RA, including change orders, were calculated for each of the sites in the database. These differences were then compared to the desired cost ranges to determine if they were within the target ranges. Factors such as the size of the projects (the final cost of the projects) and the remediation technologies used in the RAs were compared to the differences to see if they influenced the accuracy of the cost estimates or the spread of the contractors' bids.

DISCUSSION

ROD Estimate vs Actual Costs

Figure 1 presents the differences between the ROD estimates and the actual costs for RAs for 21 federal-lead superfund sites. The differences were calculated by subtracting the actual cost of the RA (including change orders) from the ROD estimate and dividing the result by the actual cost. The result was then multiplied by 100 to yield the percentage difference. The target range for the cost estimates, +50/-30 percent, is also presented on Figure 1.

For the 21 sites, 10 of the ROD estimates underestimated the final RA cost and 11 overestimated the cost. The average difference was -1 percent. In comparison to the target range, 14 (67 percent) of the cost estimates were within +50/ -30 percent of the actual cost. At only one site was the ROD cost estimate more than 50 percent greater than the actual RA cost. However, 6 of the sites underestimated the RA cost by more than 30 percent.

Figure 2 presents a plot of the absolute value of the difference between the ROD estimate and the actual site cost vs the cost of the RA. Although there is a significant amount of scatter in the data, this figure indicates a trend that, on a percentage basis, the accuracy of the ROD estimates tends to increase with the cost of the project.

For Table 3, the technologies used in the RAs for the 21 sites were divided into three categories: Alternative drinking water supplies, soil treatment or landfilling, and water treatment. From this table there appears to be a trend in the relationship between the technology used and the accuracy of the ROD estimate. All of the ROD estimates for the RAs that involved providing an alternative drinking water supply overestimated the actual RA cost. These estimates were all within the target range of +50/-30 percent. Conversely, all of the ROD estimates for the RAs that involved water treatment underestimated the actual RA cost by 19 to 55 percent. These trends may have implications for remedy selection at the ROD stage. The accuracy of the ROD estimates for the RAs which used soil treatment or landfilling did not have a trend.

Engineers' Estimates vs Actual Costs

Similar calculations were performed to compare the engineers' estimates to the actual RA costs. Figure 3 presents the differences for the 19 sites in the database with both engineers' estimates and actual costs. For the sites, 12 of the engineers' estimates overestimated the actual costs whereas only 7 of the estimates underestimated the actual costs. Only 40 percent of the engineers' cost estimates fell within the targeted range of +15/-5 percent, although the average difference was only 2 percent, which is well within the range.

Figure 4 presents a plot of the absolute value of the difference between the engineers' estimate and the actual RA cost vs the cost of the RA. This figure indicates that the accuracy of the engineers' estimates increases with the cost of the RA, on a percentage basis. This is the opposite of the trend found in a study conducted by the U.S. Army Corps of Engineers (COE) but is the same trend that was noted for the ROD estimates in this study. If Figure 4 is compared to Figure 2, it can be seen that the engineers' estimates are much closer to the actual RA costs than the ROD estimates are. So although less than half of the engineers' estimates are falling within the target range, the estimates are generally closer to the final RA costs than the ROD estimates are.

Table 4 lists the technologies used for the RAs with the percent difference between the engineers' estimates and actual RA costs. Unlike the ROD estimates, there does not appear to be any relationship between the technologies used for the RAs and the accuracy of the engineers' estimates.

Award Bids vs Actual Costs

Figure 5 shows a plot of the percent difference between the ROD estimate, the engineers' estimate, the award contractor's bid, and the actual cost of the RAs for 25 of the sites in the database. This figure shows that the ROD estimates are the furthest from the actual RA costs and that the engineers' estimates and the award bids fall within the same range of the actual costs. However, whereas the engineers' estimates on the average overestimated the actual cost by 2 percent, the award bids underestimated the costs by 7 percent. The change orders had a range of -$1.5 million

to $5.0 million for a total of $13.3 million for the 25 sites investigated. This includes the 4 sites which had negative change orders. According to the EPA and Army Corps of Engineers (ACE) sources who provided the change order data, the major source of these change orders was an increase in the amount of contamination that required remediation.

Figure 6 illustrates the spread of the contractor's bids received for the RAs. To account for the large range in the size of the projects, the bids for the sites have been plotted onto 3 graph: one for sites with bids less than $2 million, one for sites with bids between $2 and $20 million, and one for sites with bids greater than $20 million. As can be seen in the figure, there is a large spread in the contractor's bids received for each RA. In general, the highest bid was much greater than the next most expensive bid, while the low bid was fairly close to the second and third lowest bids. The low bids are the closest to the actual costs and the high bids are the furthest. The high bids are, on the average, 48 percent greater than the actual costs of the RAs. The average ratio of the high bid to the low bid was 1.7 to 1.

CONCLUSIONS

The conclusions that can be drawn from the above discussion of the information in the bid tabs database include:

A majority of the ROD estimates are within +50/-30 percent of the actual cost of the RA. Therefore the ROD estimating tools appear to be operating as anticipated.

For these limited data, the ROD estimates for alternative drinking water RAs consistently overestimated the actual RA cost and the water treatment RAs underestimated the actual costs. These trends may have implications for remedy selection at the ROD stage.

Less than half of the engineer's cost estimates are within the target range of +15/-5 percent of the actual RA cost, although the average difference is only 2 percent.

The accuracy of the ROD and engineer's estimates increases with the size of the RA, on a percentage basis.

The change orders for the sites in the database ranged from -$1.5 million to $5.0 million per site and were due to changes in conditions from the RI/FS data.

The average ratio of the high bid to the low bid was 1.7 to 1 and the largest ratio was 4.6 to 1.

REFERENCES

Hazardous and Toxic Waste (HTW) Contracting Problems: A Study of the Contracting Problems Related to Surety Bonding in the HTW Cleanup Program. U.S. Army Corps of Engineers, Water Resources Support Center, IWR Report 90-R-1. July 1990.

Table 1
SUMMARY OF RA COST INFORMATION IN DATABASE

Site	RA CONSTRUCTION COSTS ($1,000)						
	ROD Estimate	Engineer's Estimate	Low Bid	2nd Low Bid	3rd Low Bid	Highest Bid	Actual
Baird & McGuire	$5,862	$9,404	$10,528	$11,737	$12,545	$18,330	
Cannon Engineer	$210	$319	$114	$307	$421	$421	
Charles George LF	$13,613	$14,986	$15,567	$16,490	$18,440	$23,320	
Nyanza Chemical	$11,545	$12,884	$8,565	$10,332	$11,239	$14,199	
W. Sand & Gravel	$1,380	$1,056	$879	$925	$994	$1,275	$975
Bog Creek Farm	$6,927	$14,391	$12,407	$14,241	$14,666	$14,666	
Brewster Wellfield	$532		$569	$733	$781	$1,032	
Bridgeport Rental	$57,672	$41,455	$52,456	$56,799	$61,815	$84,984	
Caldwell Trucking	$269	$233	$199	$228	$230	$915	$245
Glen Ridge Radium		$169	$146	$166	$434	$434	
Haviland Complex	$98		$183			$183	
Helen Kramer LF	$37,525	$35,998	$55,679	$61,951	$73,899	$73,899	
Lang Property	$2,322	$4,125	$2,709	$2,946	$3,480	$4,680	$3,775
Metaltec/Aerosys.	$2,919	$3,490	$2,401	$2,741	$3,377	$7,518	$3,316
Vestal Water Sup.	$389	$1,126	$852	$865		$865	$863
Wide Beach Devel.	$8,795	$15,573	$15,500			$15,500	
Aladdin Plating	$4,461		$7,734	$8,865		$8,865	$11,000
Blosenski LF		$1,106	$1,100	$1,137	$1,162	$1,484	$1,653
Bruin Lagoon	$2,711	$4,998	$3,982	$5,299	$7,025	$9,474	
Croydon TCE Spill	$53		$48	$52		$52	$36
DE Sand & Gravel	$830	$1,215	$1,519	$2,395		$2,395	

Table 1
SUMMARY OF RA COST INFORMATION IN DATABASE

Site	RA CONSTRUCTION COSTS ($1,000)						
	ROD Estimate	Engineer's Estimate	Low Bid	2nd Low Bid	3rd Low Bid	Highest Bid	Actual
Kane & Lombard	$4,692	$3,989	$4,542			$4,542	
Lackawanna Refuse		$23,210	$15,902	$17,000	$19,286	$40,378	
Moyers Landfill		$26,828	$28,527	$31,476	$32,355	$33,891	
S. MD Wood		$1,964	$2,599	$2,925	$2,962	$3,385	$3,300
Davie LF	$3,000		$1,496	$1,573	$1,589	$2,680	$2,104
Hollingsworth	$1,017		$706	$934		$934	
Miami Drum Service			$16,328	$16,791	$19,886	$19,886	
Cemetery Dump	$1,883		$3,148	$3,277	$3,645	$4,254	$1,700
Lake Sandy Jo LF	$4,230	$2,337	$2,398	$3,039	$3,891	$3,891	$2,640
LaSalle Electrical	$34,495	$34,495	$17,605	$25,158	$27,131	$39,866	
Metamora LF	$12,000		$14,295			$14,295	
New Lyme LF	$10,842	$12,112	$13,748	$13,845	$15,572	$18,544	$15,077
Old Mill	$3,920	$5,719	$4,486	$4,544	$4,594	$7,476	$4,856
Verona Wellfield		$1,147	$1,098	$1,180	$1,633	$1,633	
Bayou Bonfouca		$3,695	$3,989	$5,504		$5,504	
Bio-Ecology Sys.	$2,497	$5,814	$3,789	$4,997	$5,086	$5,086	$5,289
Cecil Lindsey	$29	$22	$19	$25	$26	$26	$19
Crystal City	$1,600	$1,091	$1,080	$1,438	$1,465	$2,241	$1,228
Geneva Industries	$14,992	$22,526	$16,135	$16,169	$17,384	$29,831	$21,093
Odessa Chromium I	$247	$247	$170	$173	$181	$244	$170
Odessa Chromium II	$476	$476	$389	$416	$478	$601	$389

Table 1
SUMMARY OF RA COST INFORMATION IN DATABASE

	RA CONSTRUCTION COSTS ($1,000)						
Site	ROD Estimate	Engineer's Estimate	Low Bid	2nd Low Bid	3rd Low Bid	Highest Bid	Actual
Old Inger	$3,062		$4,739	$6,782	$7,487	$8,384	$5,039
Old Midland	$11,700		$13,871	$16,376	$19,199	$19,682	
Petro-Chem. Sys	$796	$2,058	$1,690	$1,998	$2,301	$3,169	$1,717
Sikes Disposal	$102,217	$94,529	$89,949	$95,440	$95,899	$98,380	
Cherokee County	$3,200	$679	$632	$724		$724	
As Trio Lidgerwood		$371	$302	$337	$351	$380	$321
As Trio Wyndmere		$176	$194	$202	$208	$233	$209
Clear Creek	$76	$121	$211	$482		$482	

Table 1
SUMMARY OF RA COST INFORMATION IN DATABASE

	RA CONSTRUCTION COSTS ($1,000)						
Site	ROD Estimate	Engineer's Estimate	Low Bid	2nd Low Bid	3rd Low Bid	Highest Bid	Actual
San Gabriel Area 1		$850	$752	$800	$831	$879	
United Chrome	$1,580	$805	$751	$1,071	$1,101	$1,154	$1,349

Table 2
RA TECHNOLOGIES IN BID TAB DATABASE

Adsorption
Air Stripping
Alternative Drinking Water Source
Capping
Dechlorination
Demolition
Drum & Debris Removal
Excavation
Extraction
Filtration
Gas Ventilation
Groundwater Recharge
Groundwater Reinjection
Groundwater Collection
Incineration
Landfill Gas Collection
Landfilling
Leachate Collection
Monitoring
Off-site Disposal
Oil-Water Separation
Precipitation
Pumping
Regrading
Reverse Osmosis
Sheet Piling
Slurry Wall
Soil Vapor Extraction
Solidification
Solids Dewatering
Solvent Extraction
Stabilization
Steam Cleaning
Subsurface Drains
Surface Controls
Thermal Treatment

Figure 1: DIFFERENCE BETWEEN ROD ESTIMATE AND ACTUAL RA COST

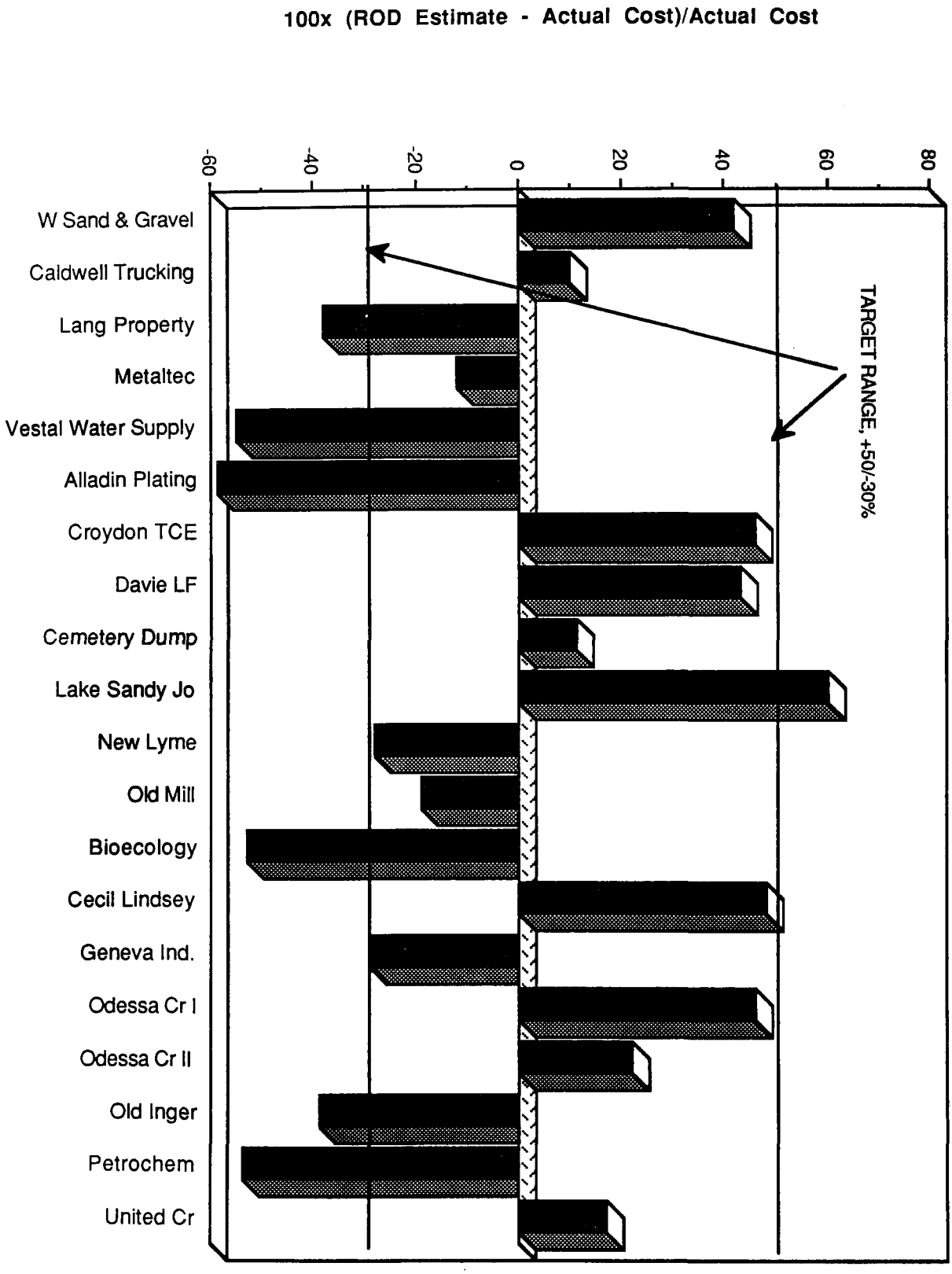


Figure 2: ACCURACY OF ROD ESTIMATE VS RA COST

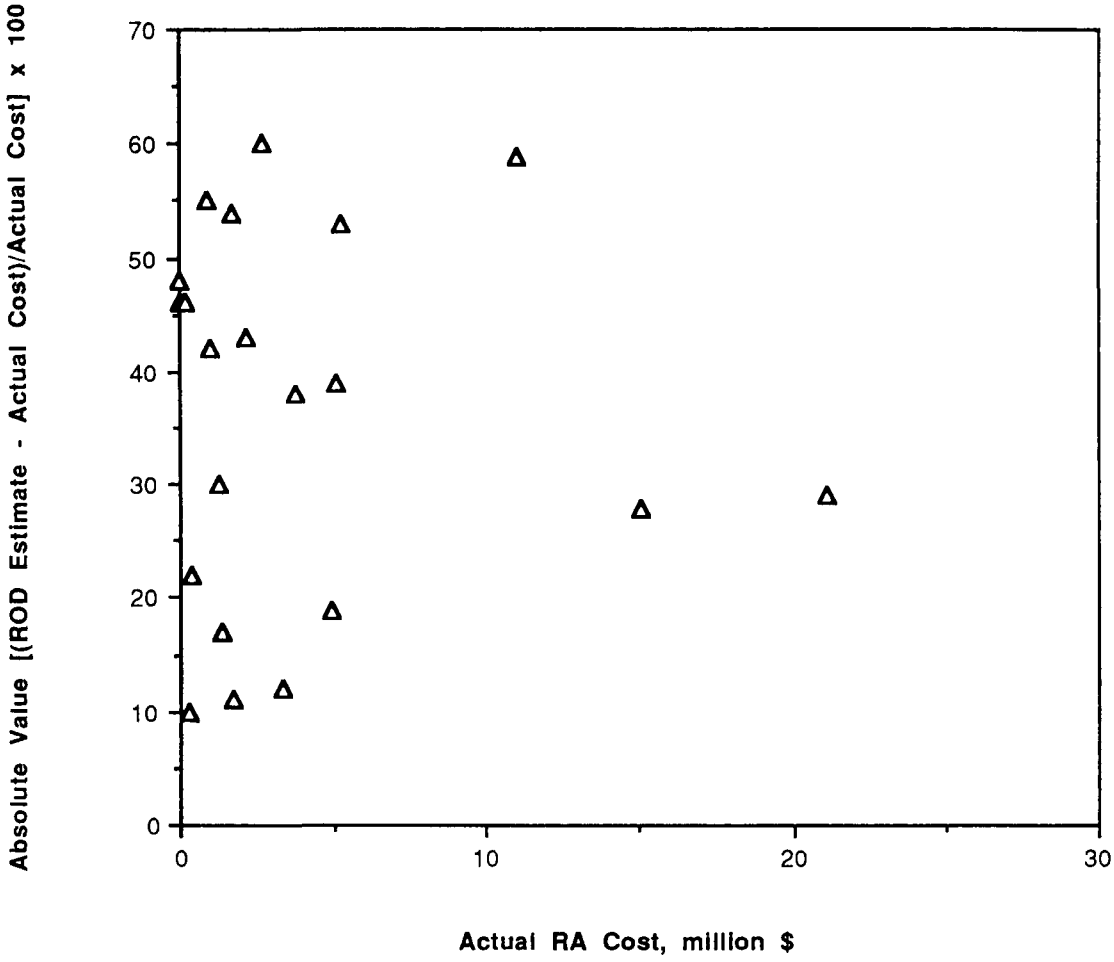


Table 3
ACCURACY OF ROD ESTIMATES VS RA TECHNOLOGY USED

Technology	Site	Accuracy of ROD Estimate (%)
Alternative Drinking Water Supply	Western Sand	42
	Caldwell Trucking	10
	Croydon TCE Spill	46
	Odessa Chromium I	46
	Odessa Chromium II	22
Soil Treatment/ Landfilling	Lang Property	-38
	Metaltec	-12
	Alladin Plating	-59
	Davie Landfill	43
	Cemetery Dump	11
	Lake Sandy Jo	60
	Old Mill	-19
	Bioecology Systems	-53
	Crystal City	30
	Cecil Lindsey	48
	Geneva Industries	-29
	Old Inger	-39
	Petrochemical Systems	-54
	United Chrome	17
Water Treatment	Vestal Water Supply	-55
	New Lyme Landfill	-28
	Old Mill	-29
	Bioecology Systems	-19
	Geneva Industries	-53
	Old Inger	-39

Figure 3: DIFFERENCE BETWEEN ENGINEER'S ESTIMATE AND ACTUAL RA COST

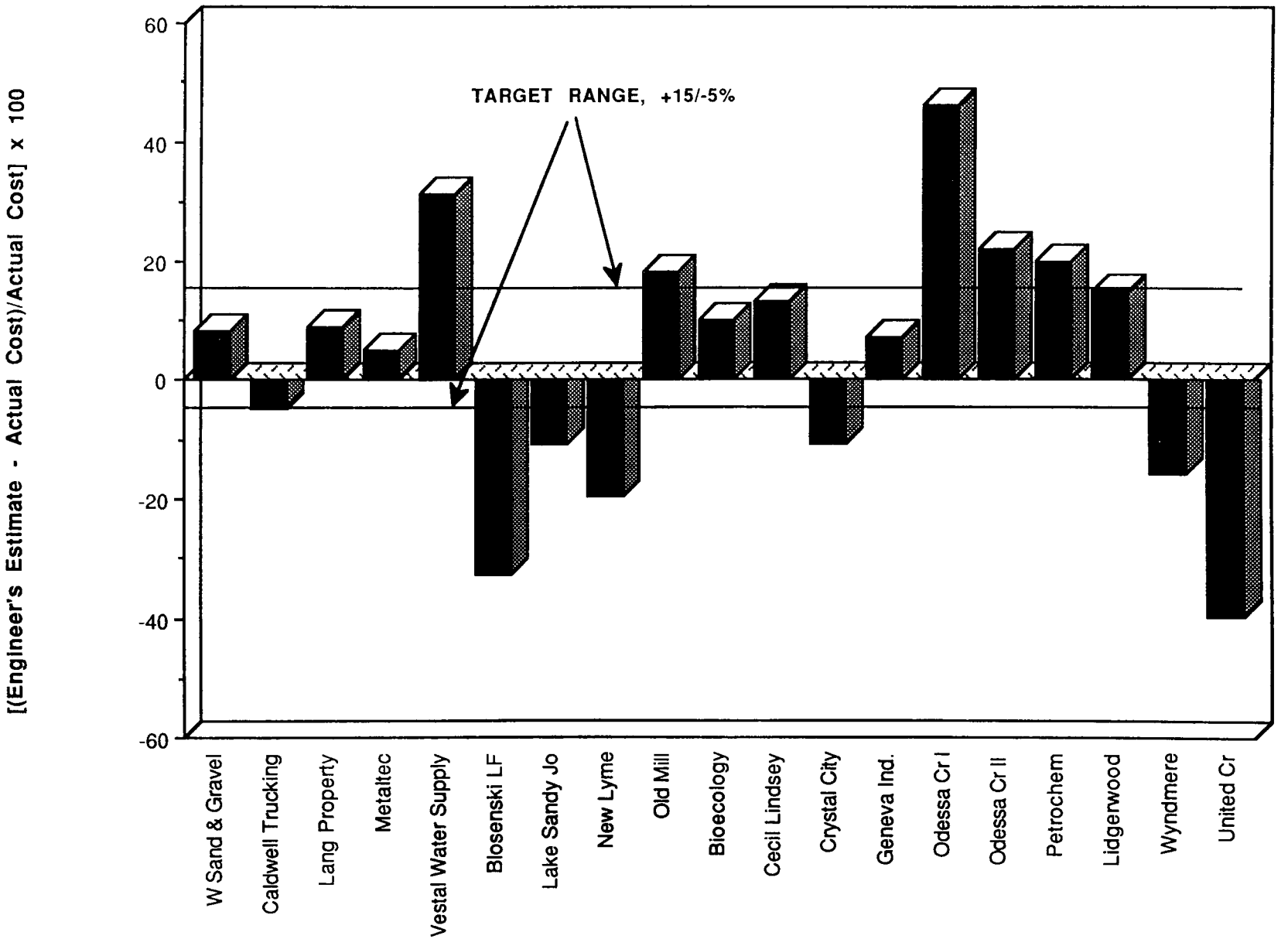


Figure 4: ACCURACY OF ENGINEER'S ESTIMATE VS RA COST

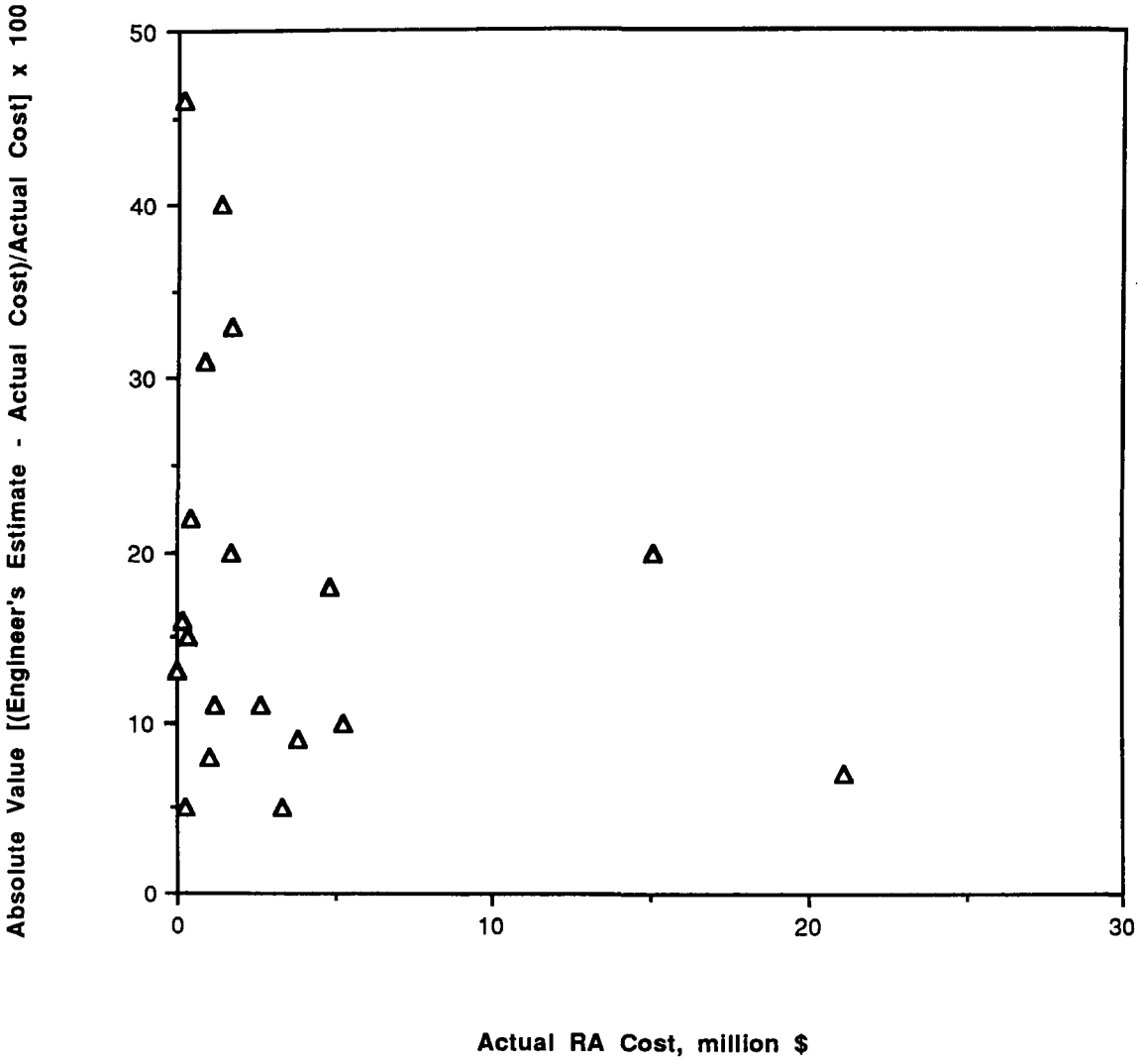


Table 4
ACCURACY OF ENGINNERS' ESTIMATES VS RA TECHNOLOGY USED

Technology	Site	Accuracy of Engineers' Estimate (%)
Alternative Drinking Water Supply	Western Sand	8
	Caldwell Trucking	-5
	Blosenski Landfill	-33
	Odessa Chromium I	46
	Odessa Chromium II	22
Soil Treatment/ Landfilling	Lang Property	9
	Metaltec	5
	Lake Sandy Jo	-11
	Old Mill	18
	Bioecology Systems	10
	Crystal City	-11
	Cecil Lindsey	13
	Petrochemical Systems	20
	United Chrome	-40
Water Treatment	Vestal Water Supply	31
	S. Maryland Wood	-40
	New Lyme Landfill	-20
	Old Mill	18
	Bioecology Systems	10
	Geneva Industries	7
	Lidgerwood	15
	Wyndmere	-16

Figure 5: DIFFERENCE BETWEEN ENGINEERS' ESTIMATE, ROD ESTIMATE, AWARD BID, AND ACTUAL COST

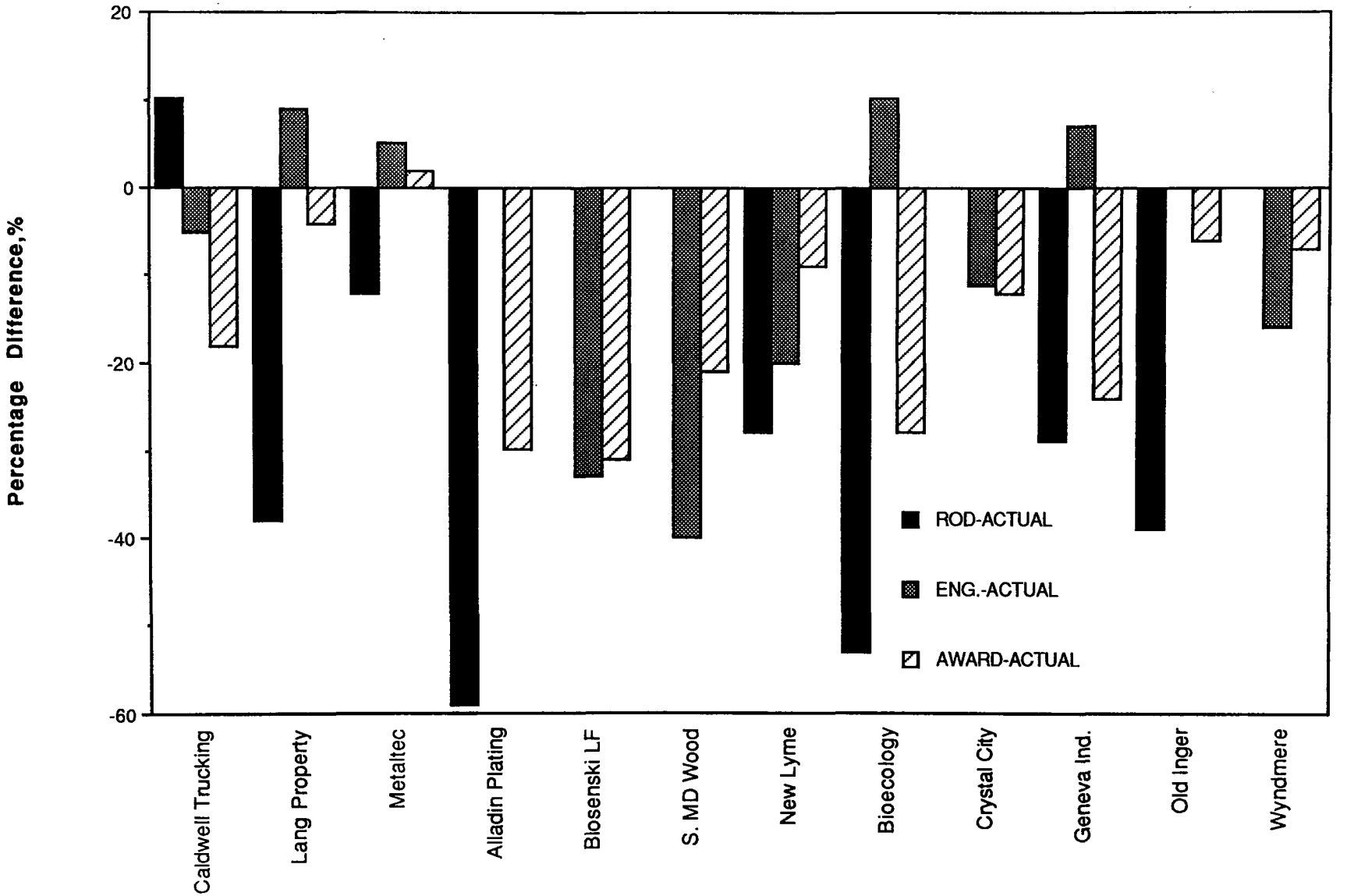


Figure 5 (Cont'd): DIFFERENCE BETWEEN ENGINEERS' ESTIMATE, ROD ESTIMATE, AWARD BID, AND ACTUAL COST

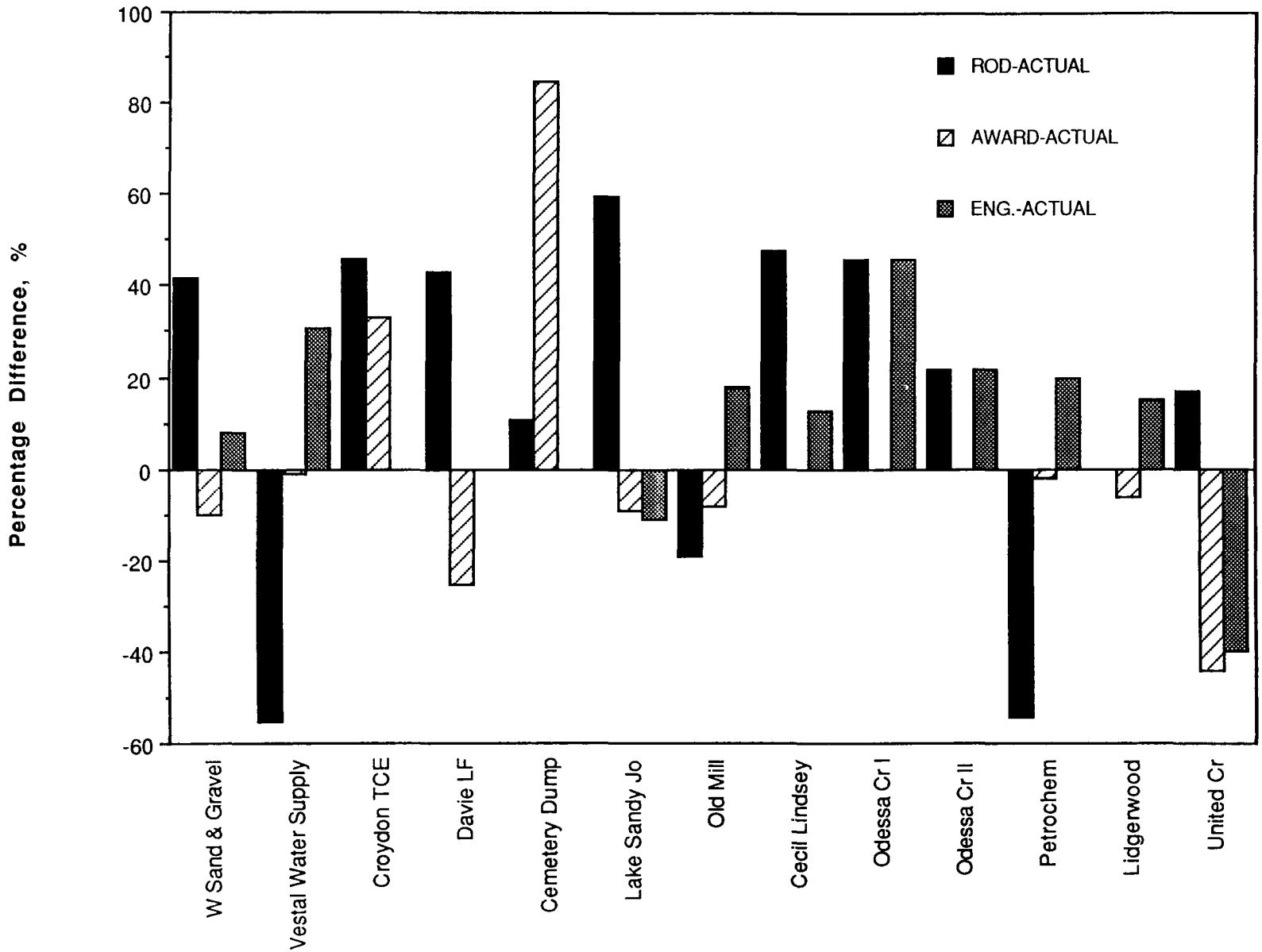


Figure 6: BIDS RECEIVED FOR SUPERFUND RAs

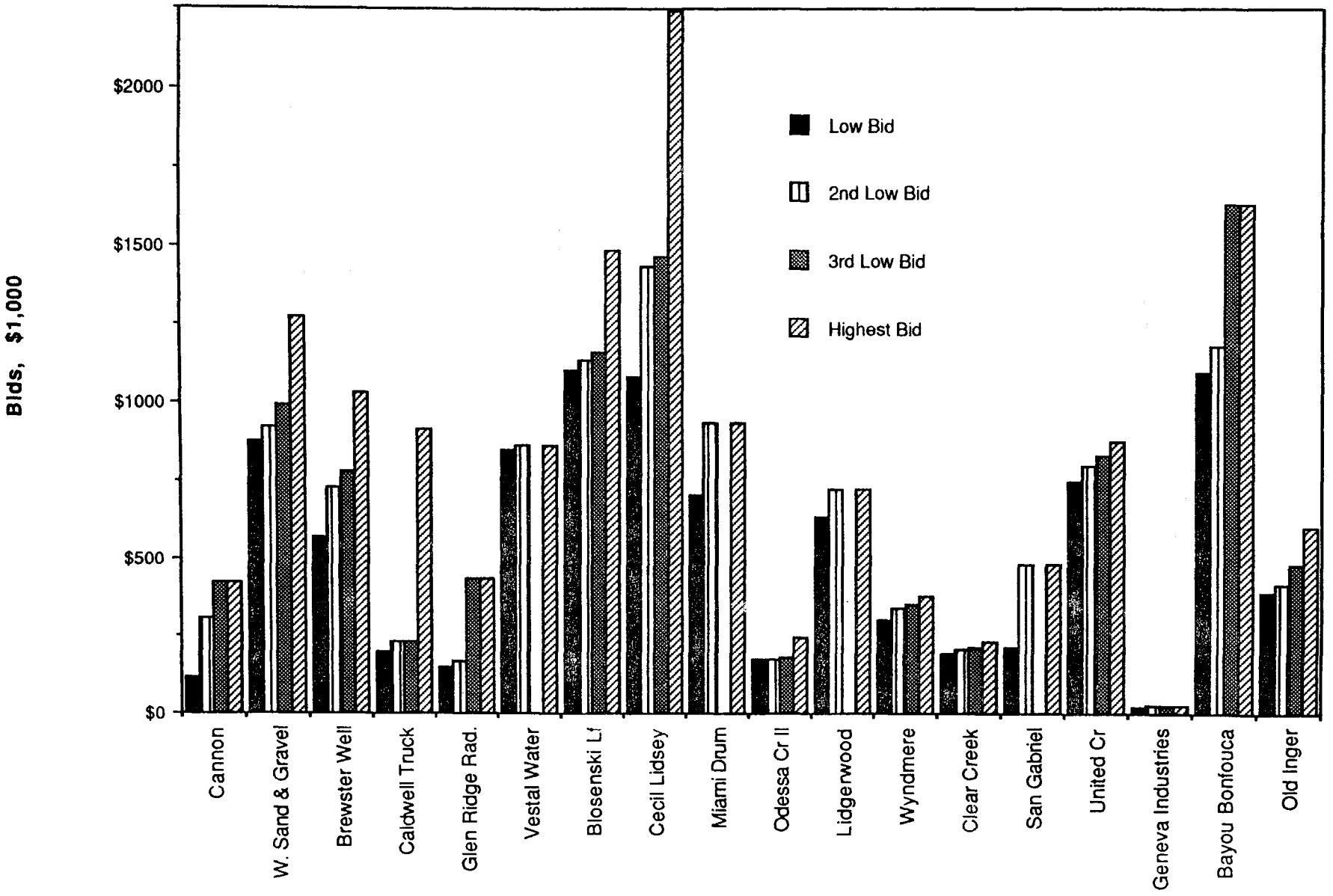


Figure 6 (Cont'd): BIDS RECEIVED FOR SUPERFUND RAs

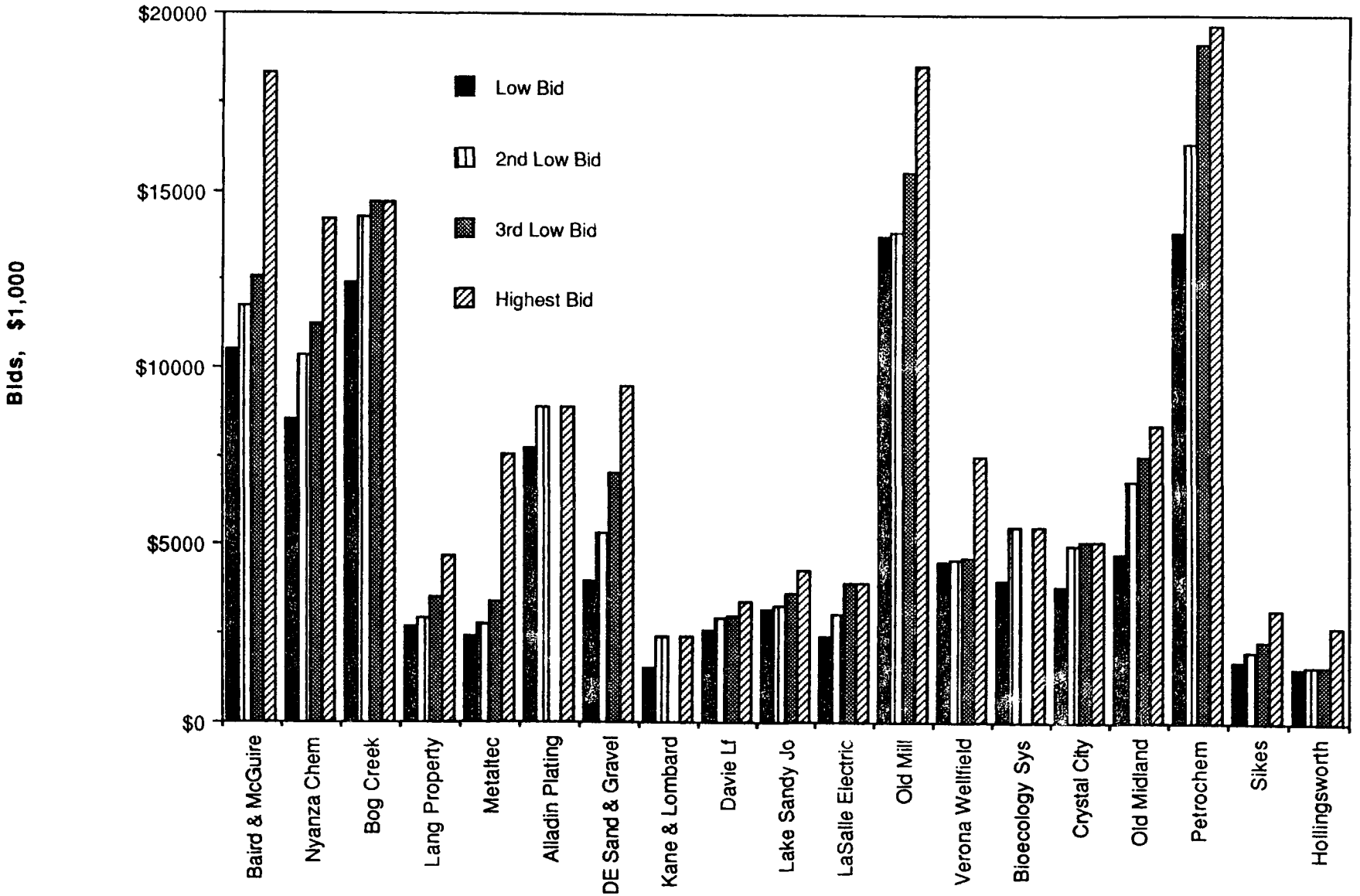
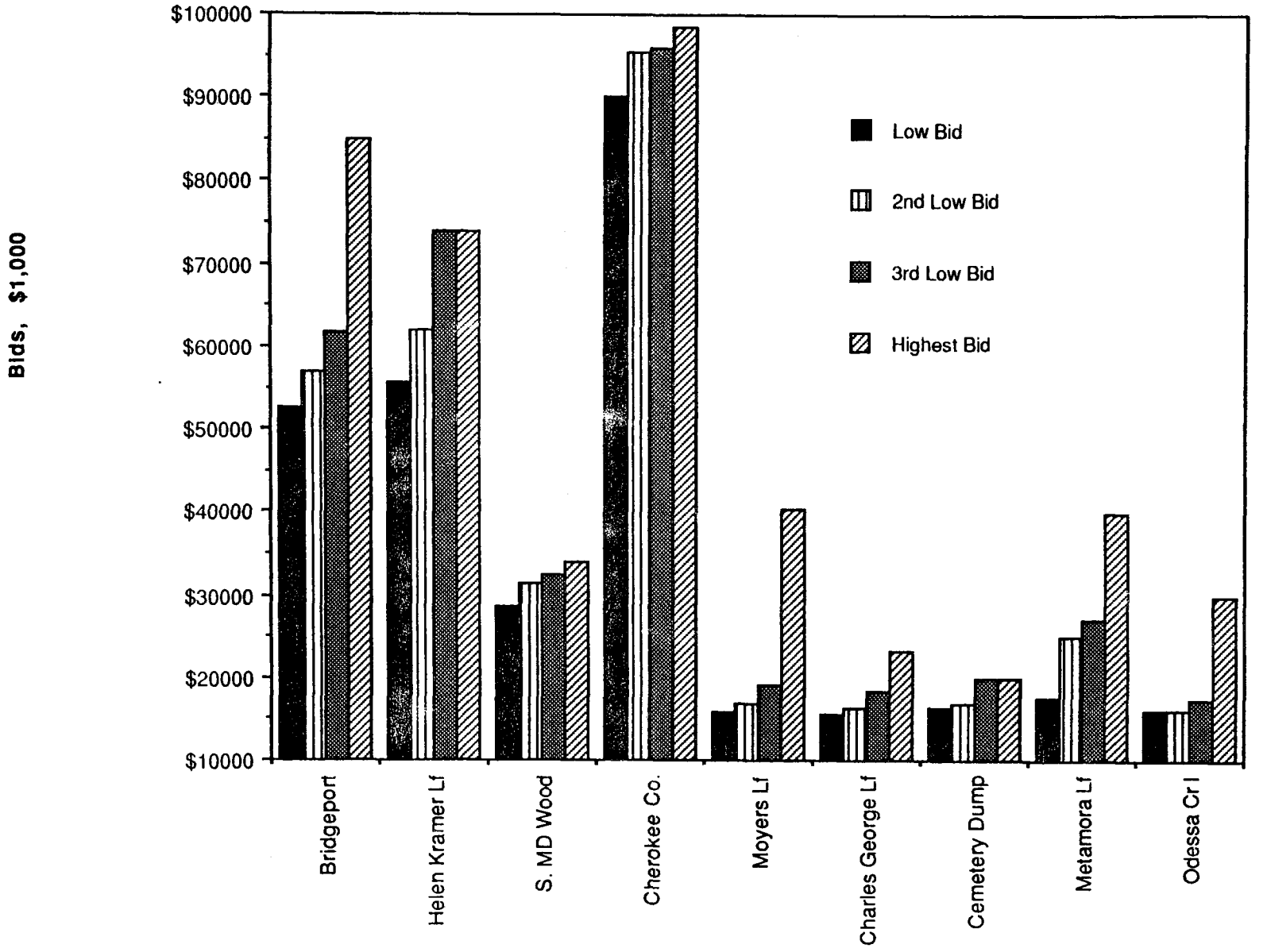


Figure 6 (Cont'd): BIDS RECEIVED FOR SUPERFUND RAs



RAC To PRP
The Thin Gray Line

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DISCLAIMER

The following paper represents only the opinions of the authors and does not necessarily represent the opinion, policy or analysis of ICF International, Inc., or its affiliated companies.

It should also be stressed that this paper only addresses the potential CERCLA liability of Response Action contractors who are performing Response Action activities under EPA contracts. It does NOT address the many additional liabilities that may apply to response activities provided on behalf of other Federal agencies or other public and private sector entities.

Finally, this paper is not intended to provide legal advice to the reader. The state of case law relating to the issues set forth in this paper is rapidly evolving and the reader should check with appropriate legal counsel with regard to any legal issues addressed herein.

INTRODUCTION

One of our military's major concerns during *Operation Desert Storm* was the danger posed by land mines placed between our troops and their objectives. Our field commanders could have taken the attitude: "Hey, war's a risky business. If you're going to get into the business, you're going to have to take the risk." But they didn't. Recognizing that the land mines constituted a dangerous threat, they took the time to evaluate and quantify the threat and then devised a broad range of countermeasures to minimize the risks. And they were successful!

Like the soldiers and Marines confronting the minefields, the response action contractor ("RAC") is engaged in an inherently risky enterprise. And as with our soldiers and Marines, it is not enough to simply say "Hey, its a risky business." The United States Environmental Protection Agency ("EPA") and RACs must take time to evaluate and quantify the risks associated with response actions and develop appropriate safeguards to ensure that EPA has access to a sufficient number of qualified RACs to perform its CERCLA responsibilities in an effective and cost efficient manner.

RACs must address the inherent risks associated with remediating hazardous substances releases on two conceptual levels. The first level involves protection of personnel, equipment and business viability from risks typically associated with traditional engineering services. This is normally provided through: (1) ongoing safety and technical programs to ensure that personnel are properly trained, (2) preventative maintenance and periodic inspections to ensure that equipment is in good working order, (3) clearly defined operating procedures and QA/QC crosschecks to ensure that procedures are being fully implemented, and (4) standard commercial insurance coverages.

The second level involves potential liability for environmental claims by third parties arising out of hazardous substance releases or associated response action activities. This second level of liability is more difficult to manage because it is almost impossible for RACs to quantify and evaluate such risks in the current legal and regulatory situation. The environmental engineering field is relatively new and many of the procedures and technologies used to characterize and measure hazardous substances are risky and unproven. The health risks associated with many hazardous substances are still unknown. Insurance to cover RAC liability risks is difficult to obtain, very expensive, and typically excludes coverage relating to pollution releases.[1] Many environmental statutes and regulations are vague and conflicting, making it difficult for the RAC to quantify and evaluate the potential liabilities to which it may be exposed in performing remediations.

It is this second level of risk, relating to potential third party claims for damage resulting from a pollution release, that is addressed in this paper. More specifically, the focus will be on risks associated with RACs' arranging for the transportation and disposal of removed or remediated hazardous substances under CERCLA in support of EPA response action contracts.

First, the legal liabilities associated with disposal of removed and remediated hazardous substances will be examined. Second, the special status of RACs will be examined within the context of CERCLA liability. Third, the legal risks to RACs who become involved in the decision-making process relating to the transportation and disposal of hazardous substances will be evaluated. Finally, specific recommendations will be made with regard to actions to more effectively quantify and evaluate the risks faced by contractors performing CERCLA remediation for EPA, with a view toward ensuring that EPA can continue to obtain such services on a cost-effective basis.

BACKGROUND

CERCLA[2] was enacted in 1980 in response to the dangers posed by the sudden or otherwise uncontrolled release of hazardous substances, pollution and contaminants into the environment from abandoned dumps, unregulated landfills and other facilities not covered by the Solid Waste Disposal Act of 1965[3] ("SWDA"), as amended by the Resource Conservation and Recovery Act of 1976[4] ("RCRA"), and other federal environmental statutes.[5] CERCLA provides a federal statutory framework for identifying, evaluating, and remediating polluted sites and for allocating the responsibility for payment of the associated costs of such response actions. EPA has been given the primary regulatory authority for the implementation of CERCLA.[6]

CERCLA authorizes EPA to initiate removal[7] and remedial action[8] whenever there is a release or substantial threat of release of a "hazardous substance" into the environment or whenever there is a release or threat of a release of a "pollutant" or "contaminant" that may cause an imminent and substantial danger to public health.[9] In performing its functions under CERCLA, EPA has contracted with private sector engineering and construction firms to obtain assistance in performing these response actions. In an effort to improve efficiency and reduce the administrative burden on EPA employees, at least one EPA Region appears to be attempting to shift responsibility for arranging for disposal of hazardous substances to RACs under EPA contracts such as the Alternative Remedial Contracts Strategy or "ARCS".[10] Since the CERCLA-related liabilities associated with the transportation and disposal of hazardous substances can be substantial, there is are important issues as to whether this proposed shift in responsibility could result in a substantial increase in potential liabilities for RACs and whether such a shift in liability is consistent with Congressional intent to limit the CERCLA liability of RACs that provide environmental clean-up services. This is an example of the types of issues with which this paper will be most concerned.

DISCUSSION

A. The Concept of Potentially Responsible Parties

1. Legislative History

One of the fundamental premises underlying CERCLA is that the parties who commercially benefit from activities that lead to releases or threatened releases of pollution should bear responsibility for the costs of these releases.[11] This is reflected in the legislative history of CERCLA. As stated by the Senate Committee on Environment and Public Works:

> The goal of assuring that those who caused the chemical harm bear the cost of that harm is addressed in [S. 1480] by the imposition of liability. Strict liability, the foundation of S. 1480, assures that *those who benefit financially from a commercial activity internalize the health and environmental costs of that activity* into the cost of doing business. Strict liability is an important instrument in *allocating the risks* imposed upon society by the manufacture, use, and disposal of inherently hazardous substances . . . .
>
> To establish provisions of liability any less than strict, joint, and several liability would be to condone a system in which innocent victims bear the burdens of releases, while those who conduct commerce in hazardous substances which cause such damage benefit with relative impunity.[12] (emphasis added)

The Congressional debates on CERCLA further expanded on this point. As noted in *Ohio v. Georgeoff*,:

> EPA argued that "society should not bear the cost of protecting the public from hazards produced in the past by a generator, transporter, consumer, or dump site owner-operator who has profited or otherwise benefitted from commerce involving these substances and now wishes to be insulated from any continuing responsibilities for the present hazards to society that have been created . . . . [R]elieving industry of responsibility establishes a precedent seriously adverse to the public interest . . . ." S. Rep. No. 848, 96th Cong., 2d Sess. 98 (1980). On the Senate floor, Senator Chaffee stated that "governments must have a tool for holding liable those who are responsible for those costs." Cong. Rec. S 15,003 (daily ed. Nov. 24, 1980). *See also, id.* S.14,971 (remarks of Sen. Tsongas); *id.* at S.14,971-72 (remarks of Sen. Bradley); Cong. Rec. H 11,799 (daily ed. Dec. 3, 1980) (remarks of Rep. Jeffords).[13]

Subsequent cases have reaffirmed this goal of holding those who commercially benefit responsible for any losses resulting from their commerce in hazardous substances. As noted in *United States v. Aceto Agricultural Chemicals Corp.*, "CERCLA places the ultimate responsibility for cleanup on 'those responsible for problems caused by the disposal of chemical poisons.'"[14]

2. CERCLA Classification of Potentially Responsible Parties

To accomplish the goal of holding those who benefit financially from certain activities accountable for any environmentally-related losses associated with those activities, CERCLA section 107(a) provides four categories of activities that cause the party conducting the activity to *automatically* become a potentially responsible party ("PRP")[15] and strictly liable under CERCLA. These categories are:

(1) the owner and operator of a vessel or a facility,

(2) any person who at the time of disposal of any hazardous substance owned or operated any facility at which such hazardous substances were disposed of,

(3) any person who *by contract, agreement or otherwise arranged for disposal or treatment, or arranged with a transporter for transport for disposal or treatment, of hazardous substances* *owned or possessed by such person*, by any other party or entity, at any facility or incineration vessel *owned or operated by another party* or entity and containing such hazardous substances, and

(4) any person who *accepts or accepted any hazardous substances for transport to disposal or treatment facilities*, incineration vessels or sites selected by such person, from which there is a release, or threatened release which causes the incurrence of response costs, of a hazardous substance . . . . [16] (emphasis added)

3. Owners and Operators

The first two categories in section 107(a) relate to the "owner *and* operator" (section 107(a)(1)) and the "owner *or* operator" (section 107(a)(2)), respectively, of any "facility."[17] "Owner *or* operator" is defined (in part) in section 101(20)(a)(ii) as "[A]ny person owning *or* operating . . . [a] facility . . . ."[18] Facility is defined (in part) in section 101(9)(B) as "[A]ny site or area where a hazardous substance has been deposited, stored, disposed or, or placed, or otherwise come to be located . . . ."[19] In addition to these rather broad statutory definitions, the terms "owner or operator" and "facility" have also been liberally construed by the courts in accordance with CERCLA's remedial intent.[20]

The two status categories set forth in sections 107(a)(1)-(2) essentially focus on "generators" of the released hazardous substance.[21] Although "generator" is a RCRA term of art, it is also frequently applied as a generic term to anyone who has commercially benefitted in connection with the hazardous substances involved in the "release" event.[22] Under sections 107(a)(1)-(2), liability attaches to anyone who owned or operated the facility at the time of the "disposal,"[23] as well as anyone who *currently* owns or operates the facility.[24]

The RAC liability issues discussed in this paper focus on the remaining two section 107(a) PRP categories: (1) those who *arrange* for transportation of hazardous substances for treatment and/or disposal and (2) those who actually transport such hazardous substances to a treatment/disposal facility that they selected.

4. Persons Who Arrange for Transport for Treatment and/or Disposal

It is critical that response contractors and other persons who perform environmental clean-up work under EPA contracts understand the elements and implications of section 107(a)(3) in order to gauge their potential liability under CERCLA. Response contractors are frequently asked to perform projects on a "turnkey" basis. Where this responsibility includes *making the decisions* regarding the arrangements for the transportation and disposal of hazardous substances, unwary response contractors may inadvertently be assuming a dramatic increase in liability risk under CERCLA without sufficient offsetting compensation.

Under section 107(a)(3), "covered persons" (i.e., potentially responsible parties or "PRPs") include:

> [A]ny person who *by contract*, agreement or otherwise *arranged for disposal or treatment, or arranged with a transporter for transport for disposal or treatment, of*

> *hazardous substances* owned or possessed by such person, by any other party or entity, at any facility or incineration vessel *owned or operated by another party* or entity and containing such hazardous substances . . . .[25] (emphasis added)

The District Court in *United States v. Ward* enumerated the requirements for a prima facie finding of CERCLA liability under section 107(a)(3) as follows:

> In order to establish liability under section 107(a)(3) the government must prove: (a) the defendant was a person within the meaning of the statute; (b) he owned or possessed hazardous substances; (c) he, by contract, agreement or otherwise, arranged for disposal or treatment, or arranged with a transporter for transport for disposal or treatment of those substances at a facility; (d) there was a release or threatened release of a hazardous substance at the site; (e) the release or threatened release caused the incurrence of response cost.[26]

As set forth in *Ward*, the first element in establishing section 107(a)(3) status is whether the party sought to held liable is a "person" as defined by CERCLA. Section 101(21) broadly defines "person" to include an "[I]ndividual, firm, corporation, association, partnership, consortium, joint venture, commercial entity, United States Government, State, municipality, commission, political subdivision of a state, or any interstate body."[27] There would appear to be little which falls outside of this definition.

The second element is that the person who arranged for disposal must have "owned or possessed" the hazardous substances for which disposal was arranged. At first glance, this would appear to protect a response contractor since it could argue that it did not own or possess the hazardous substances at the time that it arranged for their disposal (i.e., the hazardous substances were still "owned or possessed" by the client - either EPA or the PRP). In fact, some early cases seemed to indicate that *actual* ownership or possession of hazardous substances was required to meet the section 107(a)(3) liability requirements.[28]

However, in *United States v. Northeastern Pharmaceutical & Chemical Company, Inc.* (*"NEPACCO"*), the court made it clear that it was willing to impose "constructive" ownership or possession on those parties who had "the authority to control the handling and disposal of hazardous substances that is critical under the statutory scheme."[29] Other courts have subsequently followed the *NEPACCO* court in applying the concept of constructive ownership or possession.[30]

Note that under the third element in *Ward*, there need not have been a written contract. To become a PRP under section 107(a)(3), one need only perform any of the activities set forth in that section.[31]

Under the third element set forth in *Ward*, the person must also "arrange" for disposal or treatment or arrange for transportation of the hazardous substance for disposal or treatment. The term "arrange" is not expressly defined in CERCLA, nor is there any significant legislative history on the definition of this critical term.[32] Despite the relative lack of legislative history on this point, the courts have concluded that a liberal judicial interpretation of "arrange" is fully consistent with CERCLA's "overwhelmingly remedial" statutory scheme.[33]

The remaining part of the third element of section 107(a)(3) liability in *Ward* is that the hazardous substances must have been transported to a "facility." As noted previously, this term is so broadly defined in CERCLA that almost any arrangement which is made will involve transportation to a "facility."

The fourth element in *Ward* is a determination that the type of hazardous substance found at the facility at the time of the release or threatened release is the same as that which was disposed of by the PRP. *Once the same type of hazardous substance is identified at the site, the burden of proof shifts to the PRP to establish that the hazardous substance was not part of the PRP's original disposal.* Courts have construed section 107(a)(3) so as to make this an extremely difficult burden for defendants. The PRP must, in effect, account for 100% of its hazardous substances which were alleged to have been disposed of at the site in order to demonstrate that *its* hazardous substances were not a part of the release which is the subject of the CERCLA action.[34]

Finally, the Government must prove that there was a release or threatened release of a hazardous substance from the disposal site and that the release "causes" the incurrence of response costs. While the hazardous substance at the site must be the same kind as that which the alleged PRP disposed of, it need not be specifically identified as a part of the actual release.[35]

The *Ward* court did not allude to the additional express CERCLA requirement that the facility from which the release occurred be "owned or operated by another party."[36] (This element was not applicable to the facts involved in the *Ward* case.) The "other party" owner/operator element could be critical, however, under certain circumstances. For example, if the contractor merely moves a hazardous substance from one location to another, both of which are owned and operated by the same person, this activity would arguably be excluded from potential strict liability under section 107(a)(3) despite the fact that the contractor made the decision as to where to move the hazardous substances for the purpose of treatment or disposal.[37] The logic behind this exemption is that since the contractor is not moving the hazardous substances out of the ultimate control of the owner or operator, it should not be linked to the liability that would normally be associated with such a decision. (The "other party or entity" criteria would not have been met.)

5. Transporters of Hazardous Substances

Section 107(a)(4) focuses on those who *transport* hazardous substances: "[A]ny person who accepts or accepted any hazardous substance for transport to disposal or treatment facilities, incineration vessels or sites *selected by such person*, from which there is a release, or a threatened release which causes the incurrence of response costs, of a hazardous substance . . . ."[38] (emphasis added)

To be liable under section 107(a)(4), the transporter must:

- be a "person"
- who accepted hazardous substances for transport
- to a disposal or treatment facility *selected by the transporter*
- from which there is a release or threatened release.

As noted previously, since section 101(21) broadly defines "person" to include essentially all types of business entities, the transporter will normally be a "person" within the meaning of CERCLA.

The transporter must also "accept" the hazardous substances for the purpose of transporting to a disposal or treatment facility. (This is a factual issue.)

The third element of section 107(a)(4) liability is *tra[illegible]on* of the hazardous substance to a disposal or treatment facility. Section 101(26) broadly defines "transport" as "[T]he movement of a hazardous substance by any mode . . . ." and includes common and contract carriers.[39] As noted

in section 101(29), the terms "disposal" and "treatment" are given the meaning provided in SWDA section 1004.[40] Under SWDA section 1004(3), the term "disposal" is broadly defined to include spilling, leaking and other discharges.[41] Under SWDA section 1004(30), the term "treatment" is also broadly defined to include "any method" to change the "physical, chemical, or biological character or composition" of the hazardous material or render it nonhazardous.[42] (As noted earlier, the term "facility" is broadly construed to include almost any location to which the hazardous substance has been moved.)

Note that under section 107(a)(4), the treatment or disposal site must be "selected" by the transporter. A transporter is generally not liable during the transport phase for any release of hazardous substances which is beyond its control[43] or for any subsequent release from the facility to which the hazardous substances have been shipped.[44] In fact, section 306(b) expressly exempts the transporter from any liability under section 107(a) so long as:
(1) it has *not* selected the disposal site, (2) it is not otherwise a PRP related to the hazardous substances involved, and (3) the release has occurred subsequent to actual delivery at the facility.[45] By *selecting the disposal site*, however, the transporter is likely to acquire PRP status under section 107(a)(4). As stated in *United States. v. New Castle County*:

> The conduct which justifies the imposition of liability is the transportation to a *facility that the transporter itself selected*, presumably on the theory that such a party has actively involved itself in the process of storing or disposing of hazardous substances and should be made to share the cost of any resulting harm to the environment. A common carrier that merely delivers the substances to a location selected by another is not liable for releases at the facility, but is liable for any releases occurring during the period of transportation. 2 S. Cooke, The Law of Hazardous Wastes at section 14.01[5][e] at 14-93. [n.47]
>
> NOTE 47: It is generally accepted that, in order to find liability as a transporter under section 107(a)(4) of CERCLA, there must be a finding that the site was selected by the transporter. See generally Jersey City Redevelopment Authority v. PPG Indus. 18 Envt'l L. Rep. 20364-20366 (D.N.J. 1987).[46] (emphasis added)

By the mere act of selecting the treatment/disposal facility, therefore, the transporter can dramatically increase its potential liability under CERCLA.

The final element - whether there was a release or threatened release of hazardous substances from the selected treatment or disposal facility - is a *question of fact.*

B. The Standard of Liability for PRPs

1. Strict Liability

Courts have generally agreed that the standard of liability under CERCLA is "strict liability" even though this is not expressly stated in the statute.[47] Under the CERCLA strict liability scheme, anyone who engages in an activity which the statute proscribes under section 107 is liable even though no negligence or intentional misconduct is involved - i.e., liability attaches *without regard to fault or intent.* In so holding, the courts have relied to a large extent on the legislative history of CERCLA, which contains numerous references calling for strict liability.[48] As stated in a Senate Committee Report:

> In some of these cases the choice is not between an innocent victim and a careless defendant, but between two blameless parties. In such cases, the costs should be

borne by the one of the two innocent parties whose acts instigated or made the harm possible.[49]

It is clear that the drafters of CERCLA intended that the strict liability standard of section 311 of the Clean Water Act be applied to establish the standard for liability under CERCLA.[50] Section 101(32) refers to the "standard of liability" under section 311 of the Clean Water Act,[51] which has been interpreted by the courts as imposing a strict liability standard.[52]

The fact that the drafters clearly limited the available statutory defenses under CERCLA in section 107(b) further indicates that they intended that a standard of strict liability should apply to CERCLA.[53] Further, legislative affirmation of the strict liability interpretation can be inferred from the fact that Congress left the liability provisions essentially unchanged under the SARA amendments (with the exception of providing limited relief for RACs under certain defined circumstances).[54]

2. Joint and Several Liability

It is also now generally agreed that, although CERCLA does not expressly so provide, liability under CERCLA section 107 will be deemed to be "joint and several."[55] The theory underlying the legal concept of "joint and several liability" is essentially that the courts have recognized that there may be times when several parties may have jointly contributed to a loss as part of a common endeavor. Rather than place the burden on the injured party to determine which party caused a defined part of the loss, the injured party may bring an action against one or all of the other parties for the full amount of the claim. This has the effect of shifting the burden of identifying the other parties to the common endeavor and allocating the relative shares of the loss to the defendants who are generally in a better position to make those determinations.[56]

The Department of Justice position on this issue is consistent with the common law approach that joint and several liability applies whenever the acts of two or more persons combine to produce an "indivisible" harm.[57] The application of a common law approach to CERCLA section 107 liability was clearly intended by the drafters of CERCLA.[58]

The courts which have considered this issue have generally taken the position that joint and several liability is appropriate,[59] unless there is some reasonable basis for dividing the harm to apportion the contribution of each party.[60] One court rejected a defendant's suggestion of apportionment based solely on *volume*, noting that this approach was "arbitrary" since the offending wastes had been commingled at the site.[61] Another court adopted the apportionment scheme[62] contained in the original House CERCLA bill[63] which apportioned the damages based on the following criteria:

- The ability of the parties to demonstrate that their contribution to a discharge, release, or disposal of a hazardous waste can be distinguished.
- The amount of hazardous waste involved.
- The degree of toxicity of the hazardous waste involved.
- The degree of involvement by the parties in the generation, transportation, treatment, storage, or disposal of the hazardous waste.
- The degree of care exercised by the parties with respect to the hazardous waste concerned, taking into account the characteristics of such hazardous waste.

- the degree of cooperation by the parties with federal, state, or local officials to prevent any harm to the public health or the environment.[64]

The *NEPACCO* court, noting that both the language of CERCLA and its legislative history were not entirely clear on the issue of joint and several liability,[65] essentially endorsed this approach and decided the issue of joint and several liability on the "facts of the case" (finding liability to be joint and several since the harm was "indivisible").[66] Once a PRP has been linked with a CERCLA site, however, the burden of proof shifts to the defendant to establish that there is a reasonable basis for apportionment of the response cost.[67]

3. Right of Contribution

The legal concept of "contribution"[68] means that a party who has been found liable for the cost associated with a loss has the right to bring a legal action against other parties who had contributed to that loss in order to recover the cost associated with the portion of the loss caused by those other parties. Although CERCLA did not originally provide an express right of contribution, numerous provisions within the statute are indicative of the legislative intent that such a right was meant to exist under CERCLA.[69] For example, sections 107(i)-(j)[70] expressly retain "common law rights" and section 107(e)(2)[71] preserves any rights of action which liable parties may have based on "subrogation[72] or otherwise against any other person." Sections 111(a)(2) and 112(a)[73] also allow suits under section 107 to recover response costs incurred "by any other person . . . ."[74] Further, section 112(c)(2) specifically provides rights of subrogration to the Government, "the Fund" and to any person paying claims for damages under CERCLA in connection with a release of hazardous substances.[75]

Prior to 1986, many courts also held that parties who were liable under CERCLA had a right to contribution from other responsible parties.[76] The 1986 SARA amendments expressly provided a right to contribution from any person who is liable or potentially liable under section 107.[77]

4. Retroactive Liability

Defendants in CERCLA cases have argued that its "retroactive" effects in the imposition of liability violate the *due process* requirements of the Constitution. These arguments have been rejected by the courts.[78] In *NEPACCO*, the court held that sections 104 and 107(a) of CERCLA were *intended* to apply retroactively and that, therefore, these provisions were *presumed* to be constitutional.[79]

CERCLA section 106 orders have also been attacked as unconstitutional on the grounds that they impose liability for conduct that occurred before CERCLA was enacted, in violation of constitutional due process requirements. This argument has also been consistently rejected by the courts.[80]

C. Statutory Defenses to PRP Liability

Consistent with Congressional intent to hold those persons who commercially benefit from activities involving hazardous substances responsible on a strict liability basis, section 107(a) expressly limits PRP defenses. Under section 107(a), liability is "subject *only* to the defenses set forth in subsection (b) of this section . . . ."[81] (emphasis added) Section 107(b) provides:

> There shall be no liability under subsection (a) of this section for a person otherwise liable who can establish by a preponderance of the evidence that the

release or threat of release of a hazardous substance and the damages resulting therefrom were caused *solely* by-

(1) an act of God;

(2) an act of war;

(3) an act or omission of a third party *other than an employee or agent of the defendant, or than one whose act or omission occurs in connection with a contractual relationship*, existing directly or indirectly, with the defendant (except where the sole contractual relationship arises from a published tariff and acceptance for carriage by a common carrier by rail), if the defendant establishes by a preponderance of the evidence that
(a) he exercised due care with respect to the hazardous substance concerned, taking into consideration the characteristics of such hazardous substance, in light of all relevant facts and circumstances, *and* (b) he took precautions against foreseeable acts or omissions of any such third party and the consequences that could foreseeably result from such acts or omissions; or

(4) any combination of the foregoing paragraphs.[82] (emphasis added)

Note that in order to assert one of the section 107(b) defenses, the PRP must establish that the release or threatened release of the hazardous substances resulted *solely* from one or more of the events listed in that section. If the PRP is even *partially* responsible for the release, it is precluded from asserting any of the section 107(b) defenses.

The statutory defenses under section 107(b) are narrowly construed by the courts.[83] Since these are "defenses" which would only come into play after PRP liability had been established on a prima facie basis, the burden of proving their existence and applicability falls on the PRP.

Not only must the release have been caused *solely* by a third party who is not an employee, agent or contractor of the PRP, but also the PRP must have exercised reasonable care under the specific circumstances surrounding the release *and* taken precautions against the foreseeable acts of third parties as well as the potential results of those acts. Therefore, unless the PRP can clearly establish that the release occurred as a result of circumstances *totally beyond its control* and that it had exercised due care and took appropriate precautions, it is strictly liable for the response cost under section 107(a).

Finally, the court cases generally support the position that (at least with regard to employees and agents of a PRP) section 107(b) provides the PRP's *only* statutory defenses to strict liability under CERCLA.[84] Section 114(a) provides that CERCLA does not preempt the States from adopting more stringent liability schemes.[85]

In view of the significant potential dollar liability which can be associated with PRP status and the limited statutory defenses available to PRPs, RACs must carefully evaluate whether their activities are likely to cause them to also acquire PRP status or whether they qualify under CERCLA for any "status exemption" from federal strict liability under section 119, as discussed below.

D. "Response Action Contractors"

Going back to our opening *Desert Storm* analogy, the RAC is much like the soldier or Marine who has been tasked to clear a lane in the minefield. Contractors are hired to assist in investigating or

cleaning up a site which is *already* contaminated when they arrive. As with that soldier or Marine, the contractor usually has very limited initial knowledge of the nature, extent or condition of the "mines" that it has been asked to defuse. Similarly, in performing site environmental work under Government direction for the public benefit, the contractor would, under section 107, be assuming substantial liability risks resulting from contamination which it had no role in causing. The palpable inequity of this situation and the delay in clean-up progress caused by the general unwillingness of contractors to "step into" such site liabilities led Congress to provide in the SARA amendments for a specific status exemption from section 107 strict liability for "response action contractors."

1. The Legislative Background of Section 119

When enacted in 1980, CERCLA did not initially provide any special status for response contractors. Five years later, when the SARA amendments were being considered in Congress, there was widespread concern over the relatively slow progress of CERCLA clean-up efforts. This lack of progress was attributed in part to (1) the unwillingness of many large, experienced environmental firms to take on certain response action projects for fear of incurring joint liability with PRPs and (2) the limited availability of reasonably-priced insurance to cover CERCLA liability. (Despite the SARA changes, this situation still prevails today.)

It is now clear that EPA lacks the budget and internal resources to fully implement CERCLA without the active involvement of engineering and construction contractors.[86] To perform its mission under CERCLA, EPA must therefore have a sufficient pool of qualified response contractors who are willing to perform environmental services at realistic rates of compensation. In view of the complexity of the problems at NPL sites, it is essential that EPA be able to utilize the larger environmental engineering firms that possess the requisite multi-disciplinary resources and large-scale construction experience.

Recognizing this need, Congress was concerned that the high level of potential liability associated with removal and remediation services, combined with insufficient insurance coverage, was driving the larger firms out of this market. The larger environmental engineering firms were unwilling to put their substantial corporate assets at risk merely to obtain cost-reimbursement type contracts from EPA with fees substantially lower than those available in private markets. As a result, EPA was faced with the prospect of having to contract with an increasingly expensive pool of less capable contractors.

In 1986, Congress acknowledged the need to offer some level of protection to response contractors by including section 119 in the SARA amendments to CERCLA. This new section created a special status for "response action contractors," which is a defined term under CERCLA. Those who meet the statutory definition of "response action contractor" would now be afforded limited statutory protection from federal strict liability associated with a release or threatened release of pollution resulting from response action activities.[87]

The legislative history of section 119 provides some indication of the intended scope of the limitations on response contractor liability. The House Conference report on the final version noted that, under earlier versions, section 119 had been *broader in scope*. For example, an earlier Senate amendment had called for modifying the definition of "owner or operator" in section 101(20) to exclude "response action contractors" from liability as an owner or operator under CERCLA except to the extent that there was a release "primarily caused by the activities of such person."[88] This change was not included in the final version. Also, an earlier House amendment eliminated RAC liability under any federal *or state* law for damages resulting from non-negligent

actions of response action contractors. In the final version, section 119 coverage was limited to *federal* law.[89]

The House Conference Report also noted the limitation on the strict liability exemption in section 119(d), which provides that a potentially responsible party may not be considered a "response action contractor" with respect to a release for which it is responsible under section 107, nor does it qualify for indemnification under section 119(c).[90] Also noted in the House Conference Report was the limitation in section 119(b)(1) that the "third party" statutory defense in section 107(b)(3) is not available to potentially responsible parties with respect to any costs or damages caused by any act or omission of a "response action contractor."[91]

The rationale for RAC federal strict liability exemption in section 119(a) (and for indemnification in certain instances, as provided in section 119(c)), was discussed in an earlier House Report:

> *Under the concept of strict, joint and several liability which is applied to hazardous waste sites, any response action contractor working at that site is potentially liable for all removal and remedial costs associated with a release or threatened release of a hazardous substance from the site.* This is so even though the contractor is following the requirements set forth in its agreement with the Administrator, another Federal agency, a state or political subdivision or a potentially responsible party. *The imposition of such liability is not appropriate in these cases, and for that reason, section [119] exempts response action contractors from liability.* Even with such an exemption, insurance to cover liability arising out of the contractor's performance in carrying response action activities where the liability is caused by negligence of the contractor either cannot be obtained or is very expensive. New section [119] therefore authorizes the Administrator of EPA to indemnify response action contractors.[92] (emphasis added)

The legislative intent was to provide limitations on strict liability which would make it possible for response contractors to proceed with clean-up work without "betting the company" in the face of "evolving state and Federal laws (including CERCLA), which have increasingly subjected contractors to strict or near absolute liability standards."[93]

2. Qualifying as a "Response Action Contractor" Under CERCLA

Merely performing services related to clean-up of a contaminated site does not guarantee that the contractor will qualify for the protected status of "response action contractor" under CERCLA section 119. Several statutory requirements within CERCLA must be met first.

The first requirement is that the contractor must meet the definition of "response action contractor," as set forth in section 119(e)(2):

> The term "response action contractor" means -
>
> (A) any -
>
> (i) person who *enters into a response action contract* with respect to any release or threatened release of a hazardous substance or pollutant or contaminant from a facility and is carrying out such contract; and . . .
>
> (B) *any person who is retained or hired by a person described in subparagraph (A)* to provide any services relating to a response action.[94] (emphasis added)

Based on the language of section 119(e)(2), the contractor must qualify under each of the following elements of that clause:

1. The contractor must be a "person";

2. The contractor must enter into a "response action contract";

3. The contract must relate to a "release or threatened release of a hazardous substance or pollutant or contaminant";

4. The release must be from a "facility"; *and*

5. The alleged liability must have "resulted from" the release or threatened release to which the contractor has responded.

As noted earlier, "person" is broadly defined by section 101(21) and essentially covers virtually any type of business entity that a contractor might form.

The second element is that the contractor must enter into a "response action contract." CERCLA section 119(e)(1) defines "response action contract" as:

> [A]ny *written* contract or agreement entered into by a response action contractor (as defined in paragraph (2)(A) of this subsection) with --
>
> (A) the President;
>
> (B) any Federal agency;
>
> (C) a State or political subdivision which has entered into a contract or cooperative agreement in accordance with section 9604(d)(1) of this title; or
>
> (D) any potential responsible party carrying out an agreement under section 9606 or 9622 of this title;
>
> to provide any *remedial action* under this chapter at a facility listed on the National Priorities List, or any *removal* under this chapter, with respect to any release or threatened release of a hazardous substance or pollutant or contaminant from the facility *or* to provide any evaluation, planning, engineering, surveying and mapping, design construction, equipment, or any ancillary services thereto for such facility."[95] (emphasis added)

Therefore, in order for the response activities to fall within the technical definition of a "response action contract," the following criteria must be met:

1. The contract must be *in writing*;

2. The person performing the activities must otherwise be a RAC as defined in section 119(e)(2);

3. the work must be performed for certain narrowly-defined parties;

4. the response action must either be a "remedial action" provided at a facility listed on the National Priorities List *or* a "removal" action;[96] *or*

5. the response action contractor must be performing certain other defined services.

The "in writing" requirement is consistent with the intention in section 119 of restricting protection to *clearly defined categories.*

Implicit in the second element is a requirement that the response contractor be performing response action activities. The mere fact that the contractor is involved in a release or threatened release does not automatically entitle it to the protective provisions of section 119.

The third element requires that the contractor's client be one of the parties specifically set forth in section 119(e)(1).[97] If not, the response contractor will *not* qualify for RAC status under section 119.

The fourth element requires that, in order to qualify the contractor under section 119, the services must be:

- A remedial action performed at a facility listed on the National Priorities List;[98] or
- A removal action under CERCLA

The fourth element also requires that the contract relate to a "release or threatened release of a *hazardous substance* or *pollutant* or *contaminant*." This is consistent with section 104(a)(1), which provides authority for the Government to take remedial action under CERCLA. Section 104(a)(1) provides, in relevant part, that the Government can take such action:

> Whenever, (A) any *hazardous substance* is released or there is a substantial threat of such release into the environment, or
> (B) there is a release or substantial threat of release into the environment of any *pollutant* or *contaminant* which may present an imminent and substantial danger to the public health or welfare . . . . [99] (emphasis added)

Finally, the fourth element requires that the release occur from a "facility." As noted earlier, section 101(9) broadly defines "facility" to include essentially every location where a hazardous substance has come to be located, so it is probable that this requirement will be met in almost every case.

The fifth element lists additional types of services for which a RAC will be covered under section 119. These are consistent with section 107(d), which limits liability of those providing certain non-construction services.[100]

Assuming that the contractor has met *all* of the requirements set forth in sections 119(e)(1)-(2), it would qualify as a "response action contractor" for the limitations on federal strict liability and (where EPA has granted coverage) for indemnification.

3. Protected Activities Under CERCLA sections 119(a) and 119(c)

Section 119(a) provides limited exemption from liability for RACs, while section 119(c) allows for indemnification coverage for RACs under certain limited circumstances.[101] Section 119(a)(1) provides as follows:

> A person who is a response action contractor with respect to any release or threatened release of a hazardous substance or pollutant or contaminant from a vessel or facility *shall not be liable under this subchapter or under any other* <u>*Federal*</u> *law* to any person for injuries, costs, damages, expenses, or other liability (*including* but not limited to *claims for indemnification or contribution and claims by third parties* for death, personal injury, illness or loss of or damage to property or economic loss) which results from such release or threatened release.[102] (emphasis added)

Section 119(a)(2) provides that the above exemption from federal strict liability shall not apply in the case of a release that is caused by conduct of the RAC which is "negligent, grossly negligent, or which constitutes intentional misconduct."[103] In other words, the protection granted by section 119(a)(1) is only against federal *strict* liability.

As noted above, this exemption from strict liability is given only to "response action contractors," as defined in section 119(e)(2), which includes "any person who is retained or hired" by response action contractors.[104] Moreover, the exemption only applies to CERCLA and other *federal* law, not to *state* strict liability laws.[105] Many states have passed "mini-Superfund" statutes containing strict liability schemes, under which a contractor that qualifies as a "response action contractor" under CERCLA would nevertheless face potential liability *without regard to fault* in connection with any activities involving a contaminated site in which the state may have an interest.[106]

The wording of section 119(a)(1) would nevertheless appear to make the RAC's exemption from *federal* strict liability fairly expansive. However, section 119(a)(3)[107] notes two further limitations on the this exemption. First, "warranty" liability under federal, state, *or common* law is unaffected.[108] Second, employer obligations to employees under applicable law are not affected. RACs must therefore take special care to avoid prohibitions of certain statutes concerning worker health and safety and "right to know."[109]

Although section 119 is generally perceived to cover releases associated with the response action itself, it has been suggested that section 119 could be interpreted so as to apply only to a *pre-existing* release.[110] "New" releases which occur during the performance of the response action would, under this view, arguably not be covered by the section 119 exemption.[111]

The basis for this more restrictive interpretation of section 119 appears to be that section 119 only applies where a RAC is performing services ". . . with respect to any release [from a facility]" *and* that the section 119 limitations on liability only apply to "*[S]uch* release . . . ." (emphasis added) The terms "with respect to" and "such release" are not further defined in CERCLA.

Under this more restrictive interpretation, it is arguable that the subsequent actions of the RAC constitute a subsequent and separate "disposal" which falls outside of the section 119 relationship of the RAC to "such release."

In *Tanglewood East Homeowners v. Charles-Thomas Inc.*[112], the court determined that a developer could be liable under section 107(a)(2) despite the fact that it was not an owner or operator at the time of the original disposal of the hazardous substances constituting the release. The court reasoned that "[t]here may be *other disposals* when hazardous materials are moved, dispersed or *released* during landfill excavation and fillings."[113] (emphasis added) Thus, an action following the original release could be deemed a *subsequent* "disposal" or "release" for purposes of section 107(a)(2) liability.

Based on the reasoning set forth in the *Tanglewood* case, it could be argued that the word "such release" only applies to the original (or pre-existing) release and not to the subsequent "disposal" or "release" caused by the RAC's performance of the response action. Under this reasoning, a RAC would only be protected from federal strict liability under section 119 with respect to the pre-existing releases to which it was responding. It would not be protected under section 119 for any subsequent release.

Applying the rule of statutory interpretation that every part of a statute must be viewed as having some meaning and purpose, courts would probably reject this extremely narrow interpretation of the section 119 language "with respect to . . . such release" on the grounds that it would tend to render section 119(a) meaningless. This analysis is consistent with the legislative history of section 119, which noted that it would be "inappropriate" to apply strict liability where the RAC is merely "following the requirements set forth in its agreement with [EPA]."[114] Following this line of reasoning, RACs would be protected from federal strict liability with regard to *secondary* releases as long as they otherwise qualified under section 119.

It should be noted, however, that this issue exemplifies the ambiguities involved in CERCLA liability provisions. So long as these ambiguities remain, there will be a lingering concern on the part of the RACs as to whether the potential profits are worth the potential liability risks associated with CERCLA response actions.

4. Application of CERCLA Section 119 to Arranging for Disposal

Assuming that the contractor qualifies for RAC status under section 119(e)(2), the next issue is whether the following actions are covered by the section 119 limitations on liability:

- Arranging for the treatment and/or disposal, or arranging for the transportation for the treatment and/or disposal of hazardous substances; and

- Transporting the hazardous substances to a disposal facility selected by the transporter.

The definition of "response action contract" under section 119 includes "removal" and "remedial" actions. "Removal" and "remedial" actions, in turn, include "arranging for "disposal" and "transport" of the hazardous substances, based on the following analysis.

The section 101(23) definition of "removal" includes:

> "[T]he *disposal of removed material*, or the taking of such other actions as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment, which may otherwise result from a release or threat of release.[115] (emphasis added)

Although the term "transportation" is not specifically mentioned in the definition of "removal," it is an natural part of the disposal process. "Disposal of removed materials" is generally interpreted to mean the full range of activities involved in this process. An argument can also be made to the effect that the absence of the term "transport" in the definition of "removal," coupled with its inclusion in the definition of "remedial action," would indicate that transportation of a hazardous substance in connection with removals is not a protected activity under section 119. However, this would seem to go against the Congressional intent behind this provision discussed earlier.

The CERCLA section 101(24) definition of "remedial action" includes:

> "... offsite *transport* and offsite storage, treatment, destruction, or secure *disposition* of hazardous substances and associated contaminated materials."[116]

Note that the definition of remedial action includes both "transport" and "disposal" of the hazardous substances.

Based on the definitions for "removal" and "remedial action", these actions typically involving the disposal of hazardous substances would appear to be included in the definition of a "response action contract."

5. Limitations on Section 119 Status Arising out of Other CERCLA Provisions

Assuming that the RAC is otherwise qualified for section 119 protection, the remaining question is whether any *other* provisions of CERCLA could still preclude this protection. For example, section 107(a) provides:

> *Notwithstanding any other provision or rule of law, and subject only to the defenses set forth in subsection (b) of this section - . . . .*
>
> (3) any person who by contract, agreement, or otherwise arranged for disposal or treatment, or arranged with a transporter for transport for disposal or treatment, of hazardous substances owned or possessed by such person, by any other party or entity, at any facility or incineration vessel owned or operated by another party or entity and containing such hazardous substances, and
>
> (4) any person who accepts or accepted any hazardous substances for transport to disposal or treatment facilities, incineration vessels or sites selected by such person, from which there is a release, of a threatened release which causes the incurrence of response costs, of a hazardous substance, shall be liable . . . . [117](emphasis added)

At first glance, it would appear that the express language contained in section 107(a) is absolute in that no statutory defenses other than those expressly stated in section 107(b) may be used by a PRP as a defense to its liability under section 107(a). The liberal construction of this provision (in favor of the Government) is supported by case law.[118]

Although the express language of section 107(a) seems clear on its face, however, it must still be evaluated in the context of the entire statute, subsequent amendments to the statute, and the legislative intent supporting such subsequent amendments.

The current section 107(a) language was in the original 1980 statute. Section 119, however, was subsequently introduced as a part of the 1986 SARA amendments. If section 119 is read as amending the section 107(a) limitation on defenses, then the RAC may be able to perform the disposal and transportation activities covered by sections 107(a)(3)-(4) at the reduced level of liability provided under section 119(a).

It is clear from reading sections 107(a) and 119(d) together that a potential conflict exists between these two provisions. Since this conflict cannot be fully resolved from the expressed language of the provisions themselves, the courts are likely to look to the legislative history to resolve any

conflict or ambiguity.[119] One might ask, then, whether the legislative history of section 119(d) is sufficiently clear to override the apparent restrictions on allowable statutory defenses set forth in section 107(a).

Section 119(d) states:

> The exemption provided under subsection (a) of this section and the authority of the President to offer indemnification under subsection (c) of this section *shall not apply* to any person covered by the provisions of *paragraphs (1), (2), (3), or (4) of section 9607(a) of this title* with respect to the release or threatened release concerned *if such person would be covered by such provisions even if such person had not carried out any actions referred to in subsection (e) of this section.*[120] (emphasis added)

By applying generally accepted principles of statutory construction,[121] section 119(d) could be interpreted as providing that those persons who would *not* be liable under section 107(a) had they not carried out the covered response activities would thus be entitled to the section 119 limitations on liability if otherwise qualified. In other words, by expressly citing section 107(a) and *excluding* those persons who would *otherwise* be liable under section 107(a), Congress has clearly included within the section 119(a) status those persons who would be subject to section 107(a) liability *solely* as a result of their RAC activities.

This reading is consistent with Congressional intent to place limits on RAC liability in order to ensure that sufficient qualified contractors are available to competitive prices.

Section 104(a)(1), which was also included in the 1986 SARA amendments, also seems to support this interpretation. Section 104(a)(1) states:

> In no event shall a potentially responsible party be subject to a lesser standard of liability, receive preferential treatment, or in any other way, direct or indirect, benefit from any such arrangements as a response action contractor, or as a person hired or retained by such response action contractor, with respect to the release or facility in question.[122]

Section 104(a)(1) specifically addresses response actions performed by potentially responsible parties and states. The *pre-existing* PRPs referred to in section 104(a)(1) are expressly precluded from the section 119(a) limitations on liability. Unless section 119(a) covers the actions of RACs that would otherwise result in section 107(a) status, there would be no reason to specifically preclude preexisting PRPs from qualifying for the RAC limitations on liability. Under general principles of statutory construction, statutes should not be read to make "surplusage" of any provision.[123] Based on this principle, it is likely that the courts will read section 104(a)(1) as creating an exception under section 107(a) to the limitations on liability afforded to RACs under section 119(a).

It could also be argued that under the interpretation of sections 119(d) and 104(a)(1) address essentially the same types of restriction on PRP's qualifying for section 119(a) limitations on liability. In this event, one of the two provisions would be "surplusage". On closer examination, however, section 104(a)(1) provides a narrow exception to the section 119(a) limitation on liability. Section 104(a)(1) must be read within the overall context of section 104, which relates only to response actions by *pre-existing* PRPs. Section 119(d), on the other hand, applies to those additional parties who subsequently become PRPs independent from the RAC activities (e.g.,

successor in interest to a PRP, subsequent owner of the facility, etc.). Therefore, each of these provisions has a valid purpose in the CERCLA statutory scheme.

E. Potential RAC Liability for Subsequent Releases

1. Does the Section 119 RAC Strict Liability Exemption "Follow the Waste"?

In *U.S. v. Conservation Chemical Co.*, the court stated that "[CERCLA's] legislative history is replete with statements that generators of hazardous substances remain ultimately liable for those substances regardless of their place of disposition. In other words, the generators retain a continuing liability."[124]

The question has been raised as to whether the section 119 limitation on liability and indemnification provisions "follow the waste" to the ultimate disposal site.[125] This question has important implications for the RAC.

It would seem that RAC activities which would otherwise incur liability under sections 107(a)(3)-(4) are *exempt from strict liability* by virtue of section 119(a) for losses associated with the site of the response action. Under this analysis, RACs theoretically could still be liable, however, for *subsequent releases* from the facility to which the hazardous substances from the response action are taken for treatment and/or disposal *if* the RAC had selected the disposal facility.

Assuming that the section 119 limitations on liability do encompass the actions taken by a RAC to "arrange for the disposal and select the facility to which the wastes are to be transported, then it reasonably follows that Congress must have intended to *extend section 119 protection to include those events that directly flow from those decisions.* In other words, if the RAC's act of "arranging" is exempt from strict liability under section 119(a), and if the only connection to the subsequent release from the disposal facility is that the RAC made the arrangements, then section 119 arguably should preclude any strict liability that "resulted from" the arrangement decision. This conclusion is supported by the language of section 119 itself, which provides that the RAC is exempt from any federal strict liability which "results from" the release to which the RAC is responding. However, such a conclusion is by no means an inescapable one.

From a practical viewpoint, if courts determine that section 119 does *not* "follow the waste," such decisions could lead to the very result that section 119 was presumably introduced to prevent - the mass exodus of environmental engineering firms from the pool of RACs available to EPA for performance of contaminated site cleanups. This important question has not been definitively resolved by the courts.

2. The Nexus Issue

The theory that section 119 is intended to "follow the waste" is consistent with the concept of "nexus" as it relates to response actions performed by *governmental* agencies.

Courts in various jurisdictions have required that there must be some "nexus" (or relationship) between the owner of the hazardous substances and the person who subsequently "arranges" for the treatment/disposal of those hazardous substances.[126] As the court stated in *United States v. New Castle County*:

> In [NEPACCO and Aceto], this nexus or relationship was present due to the commercial relationship of the person fixed with arranger status (which in some

> instances was coupled with the actual control that person had over the hazardous wastes) and the hazardous wastes which were disposed. [Note 42.]
>
> Note 42. Such a relationship is certainly present in those cases where the arranger owned the hazardous substance, *see, e.g., Aceto*, 872 F.2d at 1382. It is also present in those cases where a corporate employee, such as a plant supervisor, was an arranger, *see e.g., Nepacco*, 810 F.2d at 743.

In *FMC Corp. v. Northern Pump Co.*, the court stressed, however, that the application of nexus was not unlimited and that the nexus must generally be "commercial" in nature.[127]

It is significant to note that the Court in *State of New York v. City of Johnstown, N.Y.* specifically found that the required *nexus* was *absent* in a situation where the *only* linkage between the "owner" of the hazardous substances and the state defendant was the state's performance of regulatory functions under CERCLA and its state counterpart. The *Johnstown* court held that:

> The cases clearly show that there has to be some nexus between the allegedly responsible person and the owner of the hazardous substances before a party can be held liable under 42 U.S.C. section 9607(a)(3). *See Edward Hines Lumber Company v. Vulcan Materials Company*, 685 F.Supp. 651, 656 (N.D. Ill. 1988); . . . . There is no such nexus between the State and defendant here. The State was attempting to remediate the hazardous waste problems at both sites and cannot be considered in the class of liable parties along with [the defendants].[128]

This interpretation was reaffirmed by the Court in *U.S. v. New Castle County*, in which it was again stressed that, in such cases, the governmental agencies were merely performing *regulatory functions for the benefit of the general public and did not benefit commercially* from their actions to dispose of the hazardous substances removed from the site.[129] However, the *New Castle* court took note of the holding in *Stringfellow* that the state would be held liable as a PRP where it operated a landfill to dispose of hazardous substances *owned by the state*.[130] The basis for the distinction between states' performing of "regulatory functions" versus activities "for commercial benefit is supported by section 107(d)(2).[131]

While case law on this specific point is virtually nonexistent, there would seem to be a correlation between (1) the lack of *nexus* between a governmental agency acting in its regulatory capacity and the owner or operator and
(2) the lack of *nexus* between the RAC and the owner or operator. Unlike the "commercial" contractor who seeks favorable commercial relationships with generators by providing "discount" disposal services, RACs have no commercial relationship with the PRPs at the site. In fact, the RAC actually has a strong disincentive to seek improper disposal sites since "remedial action" under section 101(24) only includes "secure disposal sites" and the RAC could potentially lose its section 119(a) protection by negligently selecting a facility that was not "secure."

From a legal perspective, the required "nexus" between the RAC and the "owner" of the hazardous substances is also absent. The RAC has no direct relationship with the PRPs at the response action site. In fact, such a relationship is *specifically* prohibited by the terms of RAC contracts with EPA.[132] The client of the RAC is the authorized governmental agency. If the governmental agency lacks the required "nexus,"[133] then by definition, the link between the owner of the hazardous substances and the RAC is broken as well. As the Court stated in *United States v. A & F Materials Co, Inc.*:

> Thus, liability for releases under [section 107(a)(3)] is not endless; *it ends* with that party who *both* owned the hazardous waste *and* made the crucial decision how it would be disposed of or treated, and by whom.[134] (emphasis added)

This position was reinforced by the Court in *FMC Corp. v. Northern Pump Co.* where the court stated:

> The original intent behind CERCLA was to impose liability upon those who caused the pollution, not to automatically radiate liability upon anyone with some nexus to the site.[135]

Since the only nexus of the RAC to the pollution is through the governmental agency acting in the performance of its authorized regulatory functions under CERCLA or the comparable state statute, such liability should not "automatically radiate" to the RAC unless the RAC negligently selects an "unsecure" treatment or disposal facility.

Congressional intent in support of this position can be inferred from the express language set forth in section 107(d)(1) where the statute clearly reflects the Congressional intent to protect those who render ". . . care, assistance, or advice . . . with respect to an incident creating a danger to public health or welfare or the environment as a result of any releases of a hazardous substance or the threat thereof."

Finally, the Congressional intent can be inferred from section 107(e)(1) which specifically precludes a PRP from seeking indemnifications relating to the release of hazardous substances from "any other person" who is not already a PRP.[136] Again, this concept is consistent with Congressional intent to hold those who "benefit commercially" from the use of hazardous substances from shifting liability to those attempting to resolve the problem.

F. Steps EPA Could Take to Resolve RAC Uncertainty Regarding Section 119

It is clear that there may be substantial risks for RACs who perform work involving contaminated sites. Currently, the nature and level of such risks are difficult for RACs to evaluate, due in part to their doubts as to the breadth of their strict liability exemption under section 119. The "meaning" of section 119 in the context of CERCLA generally is subject to varying interpretations. The legislative history is not dispositive on many points. Interpretations of CERCLA's liability provisions by the courts have been far from uniform. Given these uncertainties, it is no surprise that RACs continue to be concerned as to their legal vulnerability under CERCLA. This is no doubt reflected in decisions as to whether or not to bid for EPA remediation contracts and at what prices.

In this paper, we have identified several CERCLA provisions that are susceptible to multiple interpretations. These interpretations are crucial to the determination of potential RAC liability exposure associated with arranging for the transportation and disposal of hazardous substances. However, few of these interpretations have been fully or uniformly adopted by the courts (or by EPA).

The discussions set forth in this paper are not likely to resolve the uncertainties RACs may have as to exactly where they stand with regard to section 119 protection, but hopefully will *clarify the questions that must be resolved to optimize RAC cooperation with EPA in environmental clean-ups.* Until these questions are resolved, responsible RACs will undoubtedly take a conservative approach in making work commitments involving contaminated sites. This is only logical, given that if RACs' protection under section 119 is *less than expected*, they may well be subject to

strict, joint and several liability for any *subsequent* or *new* release or threatened release of hazardous substances in a scenario of ever-increasing liability due to on escalating response costs.[137]

EPA has a strong vested interest in minimizing any confusion regarding RACs' exemption from strict liability under section 119. Clear official guidance from EPA could help to slow the exodus of larger environmental consulting firms from the pool of available response contractors. These firms could then calculate with a greater feeling of certainty the risks associated with work involving contaminated sites. Such guidance could also help reduce the cost of cleanups since a larger pool of RACs could lead to more competition and a better cost/benefit ratio for Government expenditures in this area.

The courts have repeatedly acknowledged their *deference to EPA* with regard to the interpretation of CERCLA language relating to substantive matters.[138] By taking a more pro-active role in attempting to resolve ambiguities as to the extent of RAC exemption from strict liability under section 119, EPA could help the create the long-needed atmosphere of contractor confidence required to propel clean-up efforts along more quickly.

In this regard, EPA might consider statutory construction and policy issues such as the following:

- Do sections 119(a)(1) and (c) apply to *subsequent releases* resulting from RAC response action activities?

- Does section 119(a)(1) provide a *statutory defense* under section 107(a), despite the express language of section 107(a) limiting statutory defenses to those set forth in section 107(b)?

- Do sections 119(a)(1) and (c) "*follow the waste*" so as to protect the RAC with regard to a *post-disposal release* from a facility *selected by the RAC* pursuant an EPA contract?

- Does section 101(23) (defining "removal") encompass the *transportation of removed hazardous substances to a facility*?

EPA's clarification of these issues could resolve existing ambiguities relating to potential RAC liability under CERCLA. EPA could address these issues through:

- Use of EPA's influence with Congress to seek appropriate *statutory amendments removing ambiguities* in sections 101(23), 107(a) and 119.

- *Promulgation of clarifying regulations* on these issues to reflect EPA's interpretation and policy positions.

- Publication of formal *guidance documents* regarding these issues.

- Clarification of language in EPA contracts to more clearly define RAC status, indemnity options and exemption from strict liability.

- Coordination with Department of Justice to ensure that enforcement of CERCLA reflect EPA policy and interpretation of these issues.

CONCLUSION

As noted throughout this paper, varying interpretations of CERCLA provisions affecting RAC liability are both possible and reasonable. *Some of these interpretations would indicate that the RAC's exemption from strict liability could be more limited than is generally perceived.* Other interpretations, as noted herein, would indicate less potential liability exposure for RACs.

CERCLA is a product of many compromises and last minute drafting changes. Due to the nature of the legislative process, many CERCLA provisions may have been *intentionally* left vague so as to obtain the necessary support for passage of the final bill. Vagueness in some CERCLA provisions is compounded by a limited legislative history and varying interpretations by well-meaning courts.[139]

The *key* issue, however, is that such ambiguities do exist and that they represent a potentially unacceptable business risk for RACs in the context of contaminated site cleanup work for the Federal Government. EPA should therefore take a pro-active role in defining the exact nature and extent of potential RAC liability associated with EPA response action contracts.

1. Even where specialized pollution coverage is available, it is filled with exclusions and typically offered only on a "claims-made" basis.

2. Comprehensive Environmental Response, Compensation and Liability Act of 1980 ("CERCLA"), Pub. L. NO. 96-510, 94 Stat. 2767 (1980) (codified as amended by the Superfund Amendments and Reauthorization Act of 1986 ("SARA"), at 42 U.S.C. §§ 9601-9675 (1982 and Supp. V 1987).

3. Solid Waste Disposal Act of 1965 (codified at 42 U.S.C. §§ 6901-6992k).

4. Resource Conservation and Recovery Act of 1976, Pub. L. No. 94-580 (1976), U.S. Code Cong. & Admin. News (90 Stat.) 2795 (codified at 42 U.S.C. §§ 6921-6939a).

5. *See* United States v. Aceto Agricultural Chemicals Corp., 872 F.2d 1373 (8th Cir. 1989) (*"Aceto"*). *See also* H.R. Rep. No. 1016, 96th Cong., 2d Sess., pt. 1 at 1, 17-22 (1980), *reprinted in* 1980 U.S. Code Cong. & Admin. News 6119, 6119-25; S. Rep. No. 848, 96th Cong., 2d Sess. 2-13 (1980).

6. *See* 47 Fed. Reg. 42,237 (1981); Exec. Order No. 12,286, 46 Fed. Reg. 9,901 (1981). *See also*, CERCLA §§ 101(2), 102(a), 42 U.S.C. §§ 9601(2), 9602(a); EPA Determinations to Initiate Response and Special Conditions, 40 C.F.R. § 300.130 (1990); Federal Agencies: Additional Responsibilities and Assistance, 40 C.F.R. § 300.175(b)(2) (1990).

7. *See* CERCLA § 101(23), 42 U.S.C. § 9601(23).

8. *See* CERCLA § 101(24), 42 U.S.C. § 9601(24).

9. *See* CERCLA § 104(a)(1), 42 U.S.C. § 9604(a)(1).

10. Alternative Remedial Contracts Strategy contracts involve response actions, including removal and remediation engineering and construction services.

11. *See* United States v. New Castle County, No. 80-489 (D.C. Del. 1989), 30 Env't Rep. Cas. (BNA) 2134. *See also* notes 12-14, *infra*, and accompanying text.

12. S. Rep. No. 848, 96th Cong., 2d Sess. 13 (1980), *reprinted in* 1 Senate Comm. on Env't and Public Works, 97th Cong., 2d Sess., A Legislative History of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (Superfund), Public Law 96-510 at 320 (1983).

13. Ohio v. Georgeoff, Case No. C81-1961 (N.D. Ohio May 3, 1983), 19 Env't Rep. Cas. (BNA) 1113, 1124 (1983); *see also* Ohio *ex rel.* Brown v. Georgeoff, 562 F. Supp. 1300 (N.D. Ohio 1983).

14. *See supra*, note 5, *Aceto*, 872 F.2d 1373 (quoting Dedham Water Co. v. Cumberland Dairy Farms, Inc., 805 F.2d 1074, 1081 (1st Cir. 1986).

15. The term "potentially responsible party" is not expressly defined in CERCLA. This term first appears in § 104(a), where it is used to identify "persons" who are potentially liable for response costs under CERCLA by virtue of being "covered persons" under §§ 107(a)(1)-(4).

16. 42 U.S.C. § 9607(a).

17. 42 U.S.C. §§ 9607(a)(1)-(2). There is nothing in the legislative history of these subsections to indicate that the use of "and" versus "or" was intended to connote a different meaning for each of the two subsections involved.

18. 42 U.S.C. § 9601(20)(a)(ii).

19. 42 U.S.C. § 9601(9)(B).

20. *See, e.g.*, U.S. v. Carolawn Co., 21 Env't Rep. Cas. 2124, 2131 (D.S.C. 1984); Edward Hines Lumber Co. v. Vulcan Materials Co., 861 F.2d 155, 157 (7th Cir. 1988).

21. "Generator" is a generic term used to identify those persons who were responsible for the "generation" of the hazardous materials relating to the release. *See* Brennan, *Joint and Several Liability for Generators Under Superfund: A Federal Formula for Cost Recovery*, 5 J. Envtl. L. 101 (1986).

22. *See* 40 C.F.R. § 300; *See also* U.S. v. South Carolina Recycling and Disposal, Inc., 653 F. Supp. 984, 1005 (D.S.C. 1984).

23. SWDA § 1004(3), 42 U.S.C. § 6903(3), defines disposal as follows:

> The term "disposal" means the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters.

See, also, Tanglewood East Homeowners v. Charles-Thomas Inc., 849 F.2d 1568 (5th Cir. 1988) (relating to subsequent disposals by virtue of movement or mixing of contaminated soils.)

24. Note that there is a potential difference between current and prior owner/operators under § 107(a). The status of a current owner or operator under CERCLA § 107(a)(1) refers to *anyone* who owns *and* operates a facility from which there has been a release or threatened release, whereas CERCLA § 107(a)(2) refers only to an owner or operator who owned or operated a facility *at the time at which such hazardous substances were disposed of at that facility.*

25. 42 U.S.C. § 9607(a)(3).

26. United States v. Ward, 618 F.Supp. 884, 889 (E.D.N.C. 1985).

27. 42 U.S.C. § 9601(21).

28. *See supra*, *Ward*, 618 F. Supp. at 889.

29. United States v. Northeastern Pharmaceutical & Chemical Company, Inc., 579, F. Supp. 823, 848 (W.D. Mo. 1984), *aff'd in part, rev'd in part on other grounds*, 810 F.2d 726, 743 (8th Cir. 1986), *cert. denied*, 484 U.S. 848 (1987) ("NEPACCO"). *See also* United States v. Aceto Agricultural Chemicals Corp., 872 F.2d 1373, 1380 (8th Cir. 1989)

30. *Aceto, supra*, note 29, 872 F.2d at 1380; Jersey City Redevelopment Authority v. P.P.G. Industries, 665 F. Supp. 1257, 1260 (D.N.J. 1987); Allied Towing v. Great Eastern Petroleum Corp., 642 F. Supp. 1339, 1350 (E.D. Va. 1986).

31. *See* 42 U.S.C. § 9607(a)(3).

32. In explaining the compromise bill that eventually contributed the "arranged for disposal" language to CERCLA, its co-author, Senator Randolph, stated that: "It is intended that issues of liability not resolved by the act, if any, shall be governed by traditional and evolving principles of common law." 126 Cong. Rec. 30,932 (1980).

33. *Aceto*, *supra*, note 30, 872 F.2d at 1380; *See also, NEPACCO*, 810 F.2d at 743; Dedham Water Co. v. Cumberland Farms Dairy, Inc., Case No. 86-1216 (1st Cir. 1986), 25 Env't. Rep. Cas. (BNA) 1153, 1159 (1986).

34. *See* United States v. Conservation Chemical Company, 619 F. Supp. 162 (W.D. Mo. 1985).

35. *Id.*

36. *See* 42 U.S.C. § 9607(a)(3).

37. *See NEPACCO*, 810 F.2d at 743.

38. 42 U.S.C. § 9607(a)(4).

39. *See* 42 U.S.C. § 9601(26), which provides, in full, as follows:

> The term "transport" or "transportation" means the movement of a hazardous substance by any mode, including pipeline (as defined in the Pipeline Safety Act), and in the case of a hazardous substance which has been accepted for transportation by a common or contract carrier, the term "transport" shall include any stoppage in

> transit which is temporary, incidental to the transportation movement, and at the ordinary operating convenience of a common or contract carrier, and any such stoppage shall be considered as a continuity of movement and not as storage of a hazardous substance.

40. 42 U.S.C. § 9601(29), *see* 42 U.S.C. § 6903.

41. 42 U.S.C. § 6903(3) defines "disposal" as follows:

> The term "disposal" means the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters.

42. 42 U.S.C. § 6903(30).

43. CERCLA § 101(20)(C), 42 U.S.C. § 9601(20)(c), provides:

> In the case of a hazardous substance which has been delivered by a common or contract carrier to a disposal or treatment facility and except as provided in section 9607(a)(3) or (4) of this title (i) the term "owner or operator" shall not include such common or contract carrier, and (ii) such common or contract carrier shall not be considered to have caused or contributed to any release at such disposal or treatment facility resulting from circumstances or conditions beyond its control.

44. *See* United States v. New Castle County, No. 80-489 (D.C. Del. 1989), 30 Env't Rep. Cas. (BNA) 2134. *See also* notes 12-14, *supra*, and accompanying text.

45. CERCLA § 306(b), 42 U.S.C. § 9656(b), provides:

> A common or contract carrier shall be liable under other law in lieu of section 9607 of this title for damages or remedial action resulting from the release of a hazardous substance during the course of transportation which commenced prior to the effective date of the listing and regulation of such substance as a hazardous material under the Hazardous Materials Transportation Act [49 U.S.C.A. App. § 1801 et seq.], or for substances listed pursuant to subsection (a) of this section, prior to the effective date of such listing: *provided, however*, that this subsection shall not apply where such a carrier can demonstrate that he did not have actual knowledge of the identity or nature of the substance released. (emphasis in original)

46. United States v. New Castle County, No. 80-489 (D.C. Del. 1989), 30 Env't Rep. Cas. (BNA) 2134, 2153 (1989).

47. *See, e.g.*, New York v. Shore Realty Corp., 759 F.2d 1032, 1042 (2d Cir. 1985); United States v. Miami Drum Services, Inc., 17 Envtl. L. Rep. (Envtl. L. Inst.) 20539 (S.D. Fla. 1986); United States v. Argent Corp., Civ. No. 83-0523 BB, 21 Env't Rep. Cas. (BNA) 1356, 1357 (D.N.M. 1984); United States v. Conservation Chemical Co., 589 F. Supp. 59 (W.D. Mo. 1984).

48. *See supra*, text accompanying notes 11-14.

49. S. Rep. No. 848, 96th Cong., 2d Sess. 34 (1980), *reprinted in* 1 Senate Comm. on Env't and Public Works, 97th Cong., 2d Sess., A Legislative History of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (Superfund), Public Law 96-510 at 320 (1983).

50. *See* 126 Cong. Rec. 30,932 (1980) (statement of Senator Randolph: "Unless otherwise provided in this act, the standard of liability is intended to be the same as that provided in section 311 of the [FWPCA]. I understand this to be a standard of strict liability.") ("FWPCA" refers to the Federal Water Pollution Control Act, 33 U.S.C. §§ 1251-1387.)

51. "The term 'liable' or 'liability' under this subchapter shall be construed to the standard of liability which obtains under section 1321 of Title 33." (i.e., § 311 of FWPCA), 42 U.S.C. § 9601(32).

52. *See, e.g.*, United States v. Le Beouf Bros. Towing Co., 621 F.2d 787, 789 (5th Cir. 1980), *cert. denied*, 452 U.S. 906 (1981); United States v. Tex-Tow, Inc., 589 F.2d 1310 (7th Cir. 1978); Burgess v. M/V Tamano, 564 F.2d 964, 982 (1st Cir. 1977), *cert. denied*, 435 U.S. 941 (1978). Courts have also held that CERCLA strict liability applies to off-site generators in CERCLA cleanup actions. *Cf.* United States v. A & F Materials Company, Inc., 578 F. Supp. 1249 (S.D. Ill. 1984); United States v. Price, 577 F. Supp. 1103 (D.N.J. 1983).

53. *See* 42 U.S.C. § 9607(b).

54. *See* 42 U.S.C. §§ 9601-9675 (Supp. V 1987).

55. *See* C. Chadd & L. Bergeson, Guide to Avoiding Liability for Waste Disposal, Corporate Practice Series (BNA) 44 (1985).

56. Black's Law Dictionary, 4th Ed. (1968)

57. *See* C. Chadd & L. Bergeson, *supra*, note 55, at 44-45. *See also NEPACCO*, 579 F. Supp. at 843-46; United States v. Chem-Dyne Corporation, 572 F. Supp. 802, 810 (S.D. Ohio 1983) (the defendant has the burden of showing the harm is capable of division); United States v. Wade, 577 F. Supp. 1326, 1338-39 (E.D. Pa. 1983); Miami Drum Services, 17 Envtl. L. Rep. (Envtl. L. Inst.) 20539 (S.D. Fla. 1986).

The Committee on Energy and Commerce specifically endorsed the *Chem-Dyne* case, referring to it as "the seminal case. . . which established a uniform federal rule allowing for joint and several liability in appropriate CERCLA cases." *See* H. Rep. No. 253(I), 99th Cong., 2d Sess. 74 (1985).

58. *See supra*, note 32.

59. *See* cases cited in note 57, *supra*.

60. *See supra*, note 57, United States v. Wade, 577 F. Supp. 1326; United States v. Ottati & Goss, Inc., No. C80-225-L, slip op. (D.N.H. Dec. 9, 1985) (burden of showing apportionment is on the party seeking to limit their liability); *Cf*. Restatement (Second) of Torts §§ 433A, 433B, 875, 881.

61. United States v. South Carolina Recycling and Disposal, Inc. Civ. No. 80-1274-6, 20 Env't Rep. Cas. (BNA) 1753, 1759 (D.S.C. 1984)

62. United States v. A & F Materials Company, Inc., 578 F. Supp. 1249 (S.D. Ill. 1984).

63. Known as the "Gore amendment." *See* Representative Gore's remarks on joint and several liability in 126 Cong. Rec. H 9463-65 (daily ed. Sept. 23, 1980). *See generally* Note, *Joint and Several Liability for Hazardous Waste Releases Under Superfund*, 68 Va. L. Rev. 1157 (1982).

64. *See* C. Chadd & L. Bergeson, *supra*, note 55, at 45-46.

65. *NEPACCO*, 579 F. Supp. at 844.

66. *Id.*

67. *See supra*, notes 60-62 and accompanying text.

68. "Contribution" essentially is the right of one joint tortfeasor to collect a proportionate share of the damages from another joint tortfeasor. *See* Restatement (Second) of Torts § 886A.

69. For a comprehensive discussion of contribution in CERCLA, *See* United States v. Conservation Chemical Company, 619 F. Supp. 162, 224-230 (noting that contribution developed as an equitable remedy, calling for courts to do what is "fair and equitable" under the circumstances (citing the Restatement of Torts § 886, Comment c)). For the CERCLA statutory implementation of this concept, *see infra*, note 73 and accompanying text.

70. 42 U.S.C. §§ 9607(i)-(j).

71. 42. U.S.C. § 9607(e)(2).

72. "Subrogation" is essentially the right to "stand in the shoes of another" for purposes of collecting on a claim.

73. 42 U.S.C. §§ 9611(a)(2), 9612(a).

74. *See* 42 U.S.C. § 9607(e)(2).

75. 42 U.S.C. § 9612(c)(2).

76. *See* Colorado v. ASARCO, 608 F. Supp. 1484 (D. Colo. 1985); United States v. Ward, 22 Env't. Rep. Cas. (BNA) 1235 (E.D.N.C. 1984); Wehner v. Syntex Agribusiness, Inc. 616 F. Supp. 27 (E.D. Mo. 1985).

77. *See* 42 U.S.C. § 9613(f) (Supp. V 1987).

78. *See* United States v. Conservation Chemical Company, 619 F. Supp. 162, 217-221 (1985) (citing United States v. Shell Oil Company, 605 F. Supp. 1064 (D.C. Colo. 1985), Ohio *ex rel.* Brown v. Georgeoff, 562 F. Supp. 1300 (N.D. Ohio 1983)).

79. *NEPACCO*, 579 F. Supp. at 839 (citing Ohio *ex rel.* Brown v. Georgeoff, 562 F. Supp. 1300 (N.D. Ohio 1983).

80. *See e.g.*, United States v. Shell Oil Co., 605 F. Supp. 1064 (D. Colo. 1985).

81. 42 U.S.C. § 9607(a).

82. 42 U.S.C. § 9607(b).

83. *See, e.g.*, United States v. Parsons, Case No. 4:88-CV-75-HLM (N.D. Ga. 1989), 30 Env't Rep. Cas. (BNA) 1160, 1162.

84. *See e.g.*, New York v. Shore Realty Corp., 759 F.2d 1032 (2d Cir. 1985).

85. CERCLA § 114(a), 42 U.S.C. § 9614(a); *See* Allied Towing v. Great Eastern Petroleum Corp., 642 F. Supp. 1339, 1350 (E.D. Va. 1986).

86. *See* Assessing Contractor Use in Superfund, Office of Technology Assessment at 3 (1989): "The dependence on contracting is an outcome of both congressional and EPA decisions in the early 1980s."

87. CERCLA § 119(a)(1), 42 U.S.C. § 9619(a)(1).

88. H.R. Conf. Rep. No. 962, 99th Conf., 2d Sess. 236 (1986)

89. *Id.* at 237.

90. *Id.* at 238.

91. *Id.*

92. H.R. Rep. No. 253(V), 99th Cong., 2d Sess. 68 (1985).

93. H.R. Rep. No. 253(III), 99th Cong., 2d Sess. 26-27 (1985). The Judiciary Committee, which issued this report, noted that insurance for response action contractors was becoming essentially non-existent. The Committee's thinking behind the indemnification and limitation of limitation of liability sections of § 119 was summarized as follows:

> In summary, this section, in combination with the new liability standards for contractors established in H.R. 2817, addresses the two major problems created by the current liability insurance shortage. First, it provides a reasonable incentive for insurers to

> provide prospective insurance to contractors. Second, it recognizes that regardless of the liability standard, it will some time before insurers can provide adequate insurance, and therefore, it provides an interim form of protection to keep the Superfund clean-up program functioning until insurers reenter the market.

94. 42 U.S.C. §§ 9619(e)(2)(A)-(B).

95. CERCLA § 119(e)(1), 42 U.S.C. § 9619(e)(1).

96. Remedial Investigation and Feasibility Study ("RI/FS") activities are generally performed under the definition of "removal action." Also, any "qualifying" activities otherwise covered by CERCLA section 119(a) must be performed at a National Priorities List site in order for the contractor to qualify for RAC status. *See*, 40 C.F.R. § 300.430 (1990); *see also* New York v. General Electric Company, 592 F. Supp. 291, 302 (N.D.N.Y. 1984):

> The liability provisions were an essential element of the statute because the Fund itself could not adequately remedy the pervasive waste problem. It is clear beyond doubt that the liability provisions are independent of the National Priorities List of sites eligible for Superfund money, since the "requirement for a National Priority List was not intended to be a limitation on liability but rather was the result of the great concern voiced by Congress that the limited trust fund monies not be used for ill-conceived or disorganized cleanup efforts." Plaintiff's Memorandum of Law in Opposition to Defendant's Motion to Dismiss Complaint at 20. *See, e.g.*, 126 Cong. Rec. S14982 (daily ed. Nov. 24, 1980) (comments of Sen. Dole); *id.* at S14978 (comments of Sen. Humphrey); *id.* at S15007 (comments of Sen. Helm).

97. This is a *critical* element which is often overlooked by response contractors, who may automatically assume they have RAC status under § 119 merely because they are performing "response actions." Although most governmental agencies would presumably fall within § 119(e)(1)(B), *performing response action services for private sector PRPs is not a protected activity unless the PRP is obtaining those services in order to comply with a § 106 administrative order or a § 122 consent order.*

98. *See* CERCLA § 105(c)(1), 42 U.S.C. § 9605(c)(1).

99. 42 U.S.C. 9604(a)(1).

100. *See* 42 U.S.C § 9607(d)(1).

101. 42 U.S.C. §§ 9619(a), (c)

102. 42 U.S.C. § 9619(a)(1).

103. 42 U.S.C. § 9619(a)(2).

104. *See* 42 U.S.C. § 9619(e)(2)(B).

105. 42 U.S.C. § 9672(a). Regarding the limits of § 119, the House Conference Report noted that "Liability which might arise under non-Federal laws, however, is untouched . . . ." It was the conferees' "hope that [§ 119 would] induce States to deal with the question of liability within their own borders." The report further "urge[d] States to take note of the Federal standards and review their own standards of liability." *See* H.R. Conf. Rep. No. 962, 99th Cong., 2d Sess. 237 (1986).

106. *See, generally*, 1989 Review of State Laws Related to Response Action Contractors, Hazardous Waste Action Coalition of the American Consulting Engineers Council. States listed as establishing "strict liability" for RACS under state statute include: California, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Kentucky, Mississippi, Missouri, Nebraska, Nevada, New Hampshire, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, Utah, and Vermont. (The specific requirements of each state vary.)

107. 42 U.S.C. § 9619(a)(3).

108. The question could arise as to whether a RAC's failure to disclaim warranties of merchantability or fitness for a particular purpose and/or consequential damages under the Uniform Commercial Code ("UCC") could, in effect, subject it to liability as severe as that of § 107(a). Generally, the UCC applies only to "goods" not services. However, one might ask whether this warranty exception could "chill" innovative contractors' efforts to introduce new technologies into environmental work unless they are able to maintain a disclaimer of responsibility for *pollution* resulting from use of such new technologies.

The legislative history of § 119(a)(2) suggests that the *intent* of this section may have been somewhat more limited in scope, i.e., that it was "designed to insure . . . that a manufacturer's warranty covering equipment employed by a response action contractor or state remains in effect." *See* H.R. Rep. No. 253(V), 99th Cong., 2d Sess. 67 (1985).

109. *See generally*, Emergency Planning and Community Right to Know Act, codified at 42 U.S.C. §§ 11,001-11,050 (1986); 40 C.F.R §§ 355-372 (1990); Occupational Safety & Health Administration (OSHA) Hazard Communication Standard, 29 C.F.R. § 19110.1200 (1990).

110. Moskowitz, *Superfund Contractor Indemnification: A Cure in Search of a Disease*, 20 Envtl. L. Rep. 10,333 (1989).

111. *Id.* at 10334.

112. *Tanglewood, supra*, note 23, 849 F.2d 1568.

113. *Id. at 1573.*

114. H.R. Rep. No. 253(V), 99th Cong., 2d Sess. 68 (1985).

115. 42 U.S.C. § 9601(23).

116. 42 U.S.C. § 9601(24).

117. 42 U.S.C. § 9607(a).

118. New York v. Shore Realty Corp., 759 F.2d 1032 (2d Cir. 1985).

119. U.S. v. Chrysler Corp., No. 88-534-CMW (D.C.Del. 1990), 31 Env't Rep. Cas. (BNA) 1997, 2002.

120. 42 U.S.C. § 9619(d).

121. As noted earlier, the courts have established several general principles for interpreting statutory language. One of these principles is that the specific exclusion of one activity in the statutory clause means, by implication, that all other related activities not expressly excluded are included.

122. 42 U.S.C. § 9604(a)(1).

123. *See* Pettis *ex rel.* United States v. Morrison-Knudsen Co., 577 F.2d 668, 673 (9th Cir. 1978).

124. *U.S. v. Conservation Chemical Co.*, No. 82-0983-CV-W-5 (D.C. Mo. 1985), 24 Env't Rep. Cas. (BNA) 1008, 1065 (1985).

125. Moskowitz, *supra*, note 110.

126. *Aceto, supra*, note 15; *NEPACCO, supra*, note 30; U.S. v. A & F Materials Co., Inc., 582 F. Supp. 842 (S.D. Ill. 1984); Edward Hines Lumber Company v. Vulcan Materials Company, 685 F. Supp. 651, 656 (N.D. Ill. 1988).

127. FMC Corp. v. Northern Pump Co., 688 F. Supp. 1285 (D. Minn. 1987).

128. State of New York v. City of Johnstown, N.Y., 701 F. Supp. 33 (N.D.N.Y. 1988).

129. *U.S. v. New Castle County, supra.*

130. *Stringfellow*, No. CIV 83-2501 JMI (MX) (Order on Directed Verdict) (California) (Special Master).

131. 42 U.S.C. § 9607(d)(2), which provides:

No State or local government shall be liable under this subchapter for costs or damages as a result of actions taken in response to an emergency created by the release or threatened release of a hazardous substance generated by or from a facility owned by another person. This paragraph shall not preclude liability for costs or damages as a result of gross negligence or intentional misconduct by the State or local government. For the purpose of the preceding sentence, reckless, willful, or wanton misconduct shall constitute gross negligence. (emphasis added)

132. The conflict of interest provisions of ARCS and other EPA remediation contracts prohibit RACs from having *any* relationship with PRPs for the site involved. *See also* applicable regulations in Federal Acquisition Regulation (FAR), 48 C.F.R. Subpart 9.5; Environmental Protection Agency Acquisition Regulation (EPAAR) 40 C.F.R. Subpart 1509.5.

133. *See, U.S. v. New Castle County, supra.*

134. *United States v. A & F Materials, Co., Inc., supra.*

135. FMC Corp. v. Northern Pump Co., 688 F. Supp. 1285 (D. Minn. 1987).

136. CERCLA §107(e)(1), 42 U.S.C. 9607(e)(1) provides:

> No indemnification, hold harmless, or similar agreement or conveyance shall be effective to transfer from the owner or operator of any vessel or facility or from any person who may be liable for a release or threat of release under this section, to any other person the liability imposed under this section. Nothing in this subsection shall bar any agreement to insure, hold harmless, or indemnify a party to such agreement for any liabiliity under this section.

137. The current cleanup cost of an NPL site is currently averaging more than $25,000,000 and increasing. *See* Note, *The Potentially Responsible Trustee: Probable Target for CERCLA Liability*, 77 Va. L. Rev. 113, 113 n.4 (1991) (citing Marzulla, Superfund 1991: *How Insurance Firms Can Help Clean Up the Nation's Hazardous Waste*, 4 Toxics L. Rep. (BNA) 685, 685-86 (1989)).

138. *See, e.g.*, Brock v. Writers Guild of America, West, Inc. 138.3., 762 F.2d 1349, 1353 (9th Cir. 1985); Comite *pro* Rescate de la Salud v. PRASA, Case No. 89-1091 (1st Cir., October 26, 1989) 30 Env't Rep. Cas. (BNA) 1473 (1989); Chevron U.S.A., Inc. v. Natural Resources Defense Council, Inc., 467 U.S. 837, 843-845 (1984); Mayburg v. Secretary of Health and Human Services, 740 F.2d 100, 106 (1st Cir. 1984); *But see*, Cardoza v. Fonseca, 480 U.S. 421, 445-48 (1987); General Electric Co. v. Gilbert, 429 U.S. 125, 141-42 (1976).

139. *See, e.g.*, Note, *"Arranging for Disposal of Hazardous Substances:" Expansive CERCLA Liability for Pesticide Manufacturers after* U.S. v. Aceto Agricultural Chemicals Corp., 35 S.D.L. Rev. 251, 259 (and sources cited in note 70 therein); Note, *Waste Not, Want Not: Arranging for Disposal" Under CERCLA Section 107(a)(3)*, 4 J. Envtl. Law and Litigation 143, 146-47 (and sources cited in note 17 therein).

An Expert System for the Analysis of Changes Claims

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ABSTRACT: The U.S. Environmental Protection Agency Superfund projects represent over $500 million of construction related environmental remediation contracts. The Department of Defense spends even more dollars on Installation restoration programs. The largest portion of these funds is committed under the Federal Acquisition Regulations (FAR) construction contract language. Due to the uncertainties when costing out the hazardous waste site projects, history shows that about 30 cents of remedial contract claim will arise for every dollar of construction funds which are committed. Most of these claims are settled at the jobsite without relying on formal dispute resolution procedures. Some of the claims, however, evolve into full blown contract disputes. The resulting litigation wastefully consumes important resources like time, money and especially project engineering talent. Many contract disputes could be avoided if the disputing parties took fast action and were better informed. Additionally. the efficiency and effectiveness of the settlement of jobsite claims could be improved if simple, quick, easy-to-obtain claims analysis were available to site engineers.

This paper reports on an ongoing research project to develop an expert system to educate and advise inexperienced site engineers about the legal consequences of construction disputes. The part of the system described in this paper is called Claims Guidance System (CGS) - Changes Guide. It evaluates the validity of claims brought under the "Changes Clause" found in the Federal Acquisition Regulations (FAR). This paper discusses the domain of application, the major design details of the system, and the auxiliary features of the system.

INTRODUCTION

The Hazardous Waste Site remedial projects from the SuperFund projects and from the Installation restoration program of Department of Defense represent billions of dollars of construction expenditures. These Government agencies' experience with previous large construction programs indicates that 30% of the total appropriated funds will be expended for unanticipated claims and disputes. Many of these claims and disputes can be avoided or their results mitigated by prompt contract administration at the construction jobsite. Analysis of contract claims requires technical knowledge, factual knowledge and legal knowledge. Field engineers have the required technical and factual knowledge but many young inexperienced engineers lack the legal knowledge necessary to analyze claims. In an ideal world, the field engineer would have ready access to timely, low cost legal

advice. In the real world, however, the engineer is often compelled to make judgements having legal ramifications without the benefit of professional legal advice. As a result of the lack of training in basic contract law, field engineers might be unaware of accepted legal bases or the resultant consequences of their decisions.

This paper presents a progress report on a project to develop an expert system program which can advise and educate an inexperienced field engineer about the legal consequences of certain contract dispute situations. The expert system assumes the role of a claims advisor and a contract dispute resolution aid. The logic of the system is built around the Federal Acquisition Regulations (FAR) language and therefore the system is suitable for EPA, Army Corps of Engineers, and other federal construction projects.

The majority of litigation that takes place in construction concerns either differing site condition, changes or delay disputes. The expert system described in this paper is designed to analyze claims which arise under the Changes clause, as found in the Federal Acquisition Regulation (FAR). The entire scope of the research effort encompasses expert systems for differing site conditions, changes and delays. (Gjertsen 1990) Previous systems focused on the Differing Site Condition (DSC) type of claims. (Diekmann 1990, Kim & Adams 1989, Kraiem 1988b). In the Changes system three overall goals were important in the design of the system:

1. To create a basic understanding in the junior field personnel of the issues surrounding the Changes clause, i.e., as an educational aid.

2. To provide a proximate evaluation of the chances for entitlement on the claim, i.e., as an evaluator or a decision-making aid.

3. To document the existing facts and views of the person analyzing the case, i.e., as a documentary aid.

We will proceed by first describing the fundamental legal principles of the domain. We then discuss the features of the system which enable it to satisfy the three design goals noted above. We end our discussion with conclusions about the success of the system thus far and recommendations for future work.

CHANGES CLAUSE CLAIMS AND ENTITLEMENT

The Changes clause provides a legal mechanism under which the Government may make unilateral changes to suit their requirements (Directed changes), and the contractor can obtain suitable compensation or equitable adjustment for the changes for actions of the government which it considers as a change (constructive changes) (Cibinic 1981). A changes clause claim is usually an attempt by the contractor to recover additional expenses that it has incurred or will incur in order to comply with a directed or constructive change.

The Changes clause specifies a number of requirements for a change to be valid. Changes must be within the scope of the work of the contract. Also, the contractor must comply with the requirements of providing adequate notice, within time limits set by the clause. Established contract interpretation guidelines are usually applied to evaluate the contents as well as the quality of the claim. These guidelines can be classified into three groups; language analysis, surrounding circumstances, and post-interpretation dispute resolution principles (Cibinic 1981). Apart from these guidelines, the contractor must satisfy several implied duties. The contractor has an implied duty to proceed with the changed work, as well as a duty to clarify patent ambiguities before submitting a bid. The contractor must have made a reasonable site inspection before bid and failure to do so will, in some

circumstances, may invalidate the contractor's claim. Superior knowledge (prior knowledge) on the part of either the Government or the contractor can tilt the case in favor of the other party.

Given this summary background it is apparent that judging the quality and validity of a Changes claim is a difficult undertaking for those field engineers who have insufficient legal training. The following sections describe how the system is structured to allow it to make this proximate evaluation.

PROXIMATE ANALYSIS

The knowledge base used in CGS has been obtained in a number of ways; from past research, literature, case law and actual experts. Valuable insight for this system has been obtained from our previous work with DISCON (Kraiem 1988a) and Claims Guidance System (Adams 1988). The knowledge for the system is organized into production rule groups and the rule groups are organized into inference trees. The purpose of the group trees is to organize the knowledge and to direct the analysis along a reasonable inferencing path. A typical rule group tree is shown in Figure 1.

As a result of our knowledge acquisition efforts we identified 20 different legal issues which were potentially applicable to change claim analysis. The complete list of legal issues is reproduced in Table 1. No single issue is determinative of the outcome of a claim. Evaluation is based on all of the facts and circumstances of each case.

1. Scope of Work
2. Implied Warranty
3. Impossibility
4. Read as a Whole
5. Prior Course of Dealing
6. Explanation Prior to Dispute
7. Interpretation Different than Intention
8. Silence as Approval
9. Normal vs. Technical Meaning
10. Enumerated List
11. Trade Practice
12. Omissions
13. Order of Precedence
14. Parole Evidence
15. Duty to Inquire
16. Contra Preferentem
17. Site Inspection
18. Superior Knowledge
19. Final Payment
20. Notice Requirements

Table 1: 20 Legal Issues

Because the Changes clause is so broad, claims can be made under it based on number of different legal theories. Some of the legal issues are appropriate for some claims and not appropriate for others. One question confronted early in the design of CGS was whether a claim would need to navigate all of the potential issues or just the subset pertinent to that particular claim. A system which forced each candidate claim to negotiate all of the issues was easier to develop. However, such a system would be wasteful of the user's time and it could lead to inappropriate reliance on irrelevant issues.

The decision was taken to design an expert system within the CGS expert system whose only job is to select the appropriate legal issues for the claim to negotiate. This expert sub-system was called SELECTOR.

SELECTOR

The SELECTOR program was developed to conduct a pre-analysis of constructive Changes claims. The reasoning used in SELECTOR initially focuses on the primary basis of the dispute. SELECTOR suggests three primary bases:

BASIS 1: The contractor has encountered difficulty in completing the work either due to a design defect (for design specs) or due to unforeseen circumstances (for performance specs).

BASIS 2: The contractor and the owner disagree on what work is called for under the contract due to some discrepancies in, or different interpretation of, the contract requirements.

BASIS 3: The contractor claims that the owner, by its action or inaction, caused the problem.

Depending upon the basis, SELECTOR then identifies the appropriate theory of recovery and chooses the appropriate contract issues to test the validity of the theory. For example, if the basis of the dispute is an alleged defect in the specification (BASIS 1- Design Spec) then the theory of recovery is "Implied Warranty of Specification". In contrast, if the dispute is based on an alleged unforeseen difficulty (BASIS 1- Performance Spec) then the theory of recovery is "Impossibility of Performance".

The theory available under BASIS 2 is "Contract Interpretation" with various sets of issues being used for different types of disagreements. Typical issues for "Contract Interpretation" are:

Read as a Whole
Order of Precedence
Trade Practice
Normal vs. Technical Meaning
Omission
Enumerated List of Items

Additionally, if there is pre-dispute evidence, then some of the following issues are also checked:

Prior Course of Dealing
Interpretation Different than Intent
Parol Evidence
Site Inspection
Superior Knowledge

Finally, if the basis of the dispute is "Owner Actions" (BASIS 3), then the guideline is "Silence as Approval" or "Superior Knowledge". Clearly, SELECTOR is more complex than the preceding paragraphs suggest, by using SELECTOR the user avoids the need to check all of the guidelines shown in Table 1.

INFERENCE MECHANISMS AND UNCERTAIN REASONING

The advantages of selector notwithstanding, a comprehensive analysis of a Changes clause claim could involve five or six different issues. Some of those guidelines might point to a valid claim; others might indicate an invalid claim. The next challenge in developing CGS was developing a suitable

inference mechanism. Several alternatives were tried before the final scheme was selected. CGS draws a conclusion from the sub-conclusions of each of the issues selected by SELECTOR. The task of the inference mechanism is to combine the various sub-conclusions into a rational overall conclusion. The approach finally used in CGS is based on two primary variables, GP and CI:

> **GP**: For each legal issue, a variable called GP (Government Position) is defined. GP measures the strength of the owner's (i.e., government's) position on a given issue on a scale of -100 (strongly against) to +100 (strongly for).
>
> **CI**: For each legal issue, a variable called CI (Certainty Indicator) is defined which is measured on a scale of 0 to 1.0. CI is the sole carrier of uncertainty in the system. Uncertainty accumulates locally (in each issue) for each CI when the user indicates some level of uncertainty regarding the input to the systems. The system allows most questions to be answered on a scale of Definitely No - Probably No - Possibly No - Unknown - Possibly Yes - Probably Yes - Definitely Yes. If the user ever chooses the Probably or Unknown responses, the CI (i.e., the level of certainty in the conclusion) is reduced.

The product of the GP and the CI values are found and tested to ensure that they pass a threshold value. The threshold serves to remove any GP values which have been so diminished by low confidence (i.e., low CI values) as to become suspect. The system potentially contains 20 GP-CI products which are then weighted and combined to form a final conclusion. The weights for each issue are chosen to reflect the relative importance most courts and Boards of Contract Appeal allocate each issue in reaching their judgments. The weights used in the current implementation of CGS are shown in Table 2. Note that the weights range from 1 to 6, where 6 represents the most significant issues.

The system uses the product of the negative GP/CI values to determine the strength of the contractor's position and the product of the positive GP/CI values to determine the strength of the owner's (government's) position. Conclusions about the results of the claim are constructed depending upon whether the respective positions are Weak, Moderate or Strong. In close cases, i.e., where both parties have cases of similar strength, the system issues a caution to that effect. Otherwise, the system concludes for the strongest party using appropriately weak or strong language, as well as language indicating the confidence of that conclusion.

Issue	Weight
1. Scope of Work	2
2. Implied Warranty	6
3. Impossibility	4
4. Read as a Whole	6
5. Prior Course of Dealing	6
6. Explanation Prior to Dispute	6
7. Interpretation Different than Intention	4
8. Silence As Approval	4
9. Normal vs. Technical Meaning	5
10. Enumerated List	5
11. Trade Practice	5
12. Omissions	5
13. Order of Precedence	5
14. Parole Evidence	3
15. Duty to Inquire	3
16. Contra Preferentem	3
17. Site Inspection	1
18. Superior Knowledge	1
19. Final Payment	2
20. Notice Requirements	2

Table 2: Weights Used for Final Conclusion

PRELIMINARY TESTING

The system for determining the final conclusions resulted from several design-test-redesign iterations. The system behavior was first tested against existing case law to ensure that its results conformed to current judicial opinion. Each version of the knowledge system was tested by four evaluators against 10 different cases from the Boards of Contract Appeals (BCA). A listing of the cases used for these analysis can be found in Appendix 1. The result from each test case was classified as belonging to one of three outcomes:

Group 1 - The system reached the same conclusion as the BCA and for the same reasons.

Group 2 - The system reached the same conclusion as the BCA but using a different line of reasoning.

Group 3 - The system reached different conclusions from the BCA

Of the 40 test cases (4x10 cases) used to evaluate the current system, 28 were correct for the correct reasons (Group 1), 3 were Group 2 and the remaining 9 cases (22.5%) resulted in conclusions which were different from the BCA (Group 3). While the 70% (28 of 40) success rate of this version of CGS is not good enough for a final system, it is good enough to encourage us to continue development. When we analyze the cases which reached inappropriate results we find that all three of the Group 2 cases and five of the nine Group 3 cases resulted from difficulties with the "Implied Warranty"

portion of the analysis. Clearly one of the priorities of this research program is to strengthen the "Implied Warranty" analysis.

The next phase of testing, which is ongoing at this time, is testing with a group of field engineers in actual field conditions. The purpose of this round of testing is not only to verify that the system gives correct answers, but also to validate the concept of the system as a training aid for inexperienced field personnel.

EXPLANATION AND TRAINING

Expert system programs have a unique capability to provide explanations of their behavior to their users. In the design of CGS we tried to capitalize on this explanation capability to provide the field engineer with a construction claims decision support environment. The importance of the training aspect of this claims guidance was best described in a treatise on legal reasoning in expert systems (Gardner 1987). According to Gardner, easy cases are settled by rules established by statutory and case law. When the accepted rules conflict with each other, then cases (the difficult cases) are settled by application of principles. CGS, like most current expert systems, is a rule based system and therefore, it is relatively adept at reaching correct "rule based" decisions for the easy cases. When CGS is faced with a case with conflicting rules the system must rely on some automated inferencing scheme to arbitrate between the conflicting rules. The current version of CGS uses the previously described system of weights, thresholds and certainty indicators. There are many other artificially intelligent approaches to uncertain reasoning and conflicting evidence (Bhatnagar 1986). We investigated several advanced approaches to automated reasoning in the course of this project and we concluded that a better long term goal was to let the people do the difficult reasoning and let the computer support the process of difficult reasoning. That is, it is very important to educate the users as to the principles involved when rules conflict so that the system queries can be answered correctly. To that end we provided the users with a continuously accessible decision support system. The support system was implemented using the "hypertext" facility of the expert system shell.

Five major features have been provided for decision support to aid the field engineer:

1 - General Information
2 - Explanation
3 - Citation
4 - Quotation
5 - Examples

Figure 2 shows a typical question screen from the system with the hypertext explanation features shown below the question. These features appear in inverse video on the screen. They can be activated either by a mouse or by a function key. The control returns to the original screen as soon as the user is done with the decision support screen and presses the spacebar.

All five decision support features are designed to help the system user gain a better understanding of the principles involved at a given point of a consultation. The General Information screen appears at the beginning of the analysis of each of the 20 issues to explain the nature of the issues and how it relates to the other issues of the analysis. The Explanation feature provides additional explanation about each question being asked as part of an issue. Explanations can include elaborations, definitions, further information on the issue and help in responding to the question. The Example feature provides hypothetical examples of the application of the principle or legal rule involved. Often these examples are taken from BCA cases. Quotations provide pertinent explanatory text found in BCA or appellate court rulings where the case provides an exceptionally lucid description of the principle or legal rule involved. The Citations feature provides a list of citation on which the other

help screens are based. Figures 3 through 7 are examples of each of the five decision support facilities included in CGS.

These decision support features are designed to help the field engineer understand the important principles. However, it is essential that the system not instill over confidence in the field engineer. We have taken great care to provide sufficient cautions in the system regarding the benefits of professional advice. Even so, there are those who criticize this work saying that it impinges on the domain of attorneys and that engineers should not make legal or quasi-legal determinations. Yet, engineers do make such determinations every day at construction projects. In developing this system, we are not trying to require engineers to make legal judgments; rather, we are attempting to improve the quality of the judgments which engineers are already required to make.

DOCUMENTATION AND REPORTING

At the end of the consultation session, the system generates a report which includes general information about the case at hand, all questions asked and their responses, all relevant information such as dates, which was provided by the user. In addition, the report includes any clarification or further information requested by the system, and all the conclusions provided by the system, and all the additional information provided by the user during the session. The final report can be provided as an ASCII text file or as a printed report. It can be used for documentation of the consultation, or it may be sent from the field office to a central claims office for review before further action by the field.

CONCLUSIONS

The Changes clause expert system is designed to provide pre-legal assistance to inexperienced site engineers in handling potential claims under the Changes clause of a standard federal construction contract. It is designed to evaluate the validity of a claim, educate the user as to the legal principles involved, and document the facts and reasoning about the claim. This expert system has been designed to function on microcomputers with standard capabilities and its intended use is to be at the actual sites of construction.

Until we have more field trials we cannot recommend how to best use the system in practice. However, several potential modes of use are possible. The most obvious mode is to allow the government's field engineering staff to use the system by all junior engineers as a means of education and to improve the quality of claims analysis. The system produces ample documentation of the facts of the case and the thoughts and reasoning of the engineer who analyzed the case. In remote locations, the system generated report can be sent on for further analysis.

Another mode of use for the CGS system is as a vehicle for alternative dispute resolution (ADR). Two mechanisms suggest themselves, a cooperative system and a competitive system. In the competitive system both parties to the dispute would have access to the system. Each side would run the system and then compare notes. If used in this way the system would serve to identify areas in which the parties agree and in which they disagree. By highlighting the areas of disagreement, the scope of the required negotiations can be limited. In the cooperative approach, both sides would run the system together. They would jointly answer the questions posed by the system. By cooperatively running the system, the two sides would be furnished with a device to facilitate a dialogue regarding the facts of the case (Kayman 1991).

We believe that CGS and its associated claims modules have potential for improving the decisions of field engineers. Much more information is available about this work. Those interested in a

comprehensive description of the Changes clause expert system are requested to refer to our previous work (Dagli 1990, Gjertsen 1990 and Rotar 1990).

ACKNOWLEDGEMENTS

The work here is the result of the efforts many people. To Dhaval, the author of the original system; to Knut who selected the SELECTOR; to Mike who kept us honest; to Michael our resident legal eagle; and to Sharon our resident conscience; Thanks. Thanks also to our committee of domain experts from the Corps of Engineers and the EPA for the contribution of their time and expertise. Finally, thanks to CERL and EPA for funding this exciting and important work.

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APPENDIX 1: LIST OF CASES

Century Constr. Co. v. United States, ASBCA 31702, 89-1 BCA (CCH) ¶ 21,333 (Oct. 18, 1988).

Trescon Corp. v. United States, ENGBCA 5253, 88-3 BCA (CCH) ¶ 21,163 (Sept. 23, 1988).

Caddell Constr. Co. v. United States, ASBCA 33792, 89-1 BCA (CCH) ¶ 21,201 (Sept. 14, 1988).

Guy F. Atkinson Co. v. United States, ENGBCA 4771, 88-2 BCA (CCH) ¶ 20,714 (Apr. 29, 1988).

Robert E. McKee, Inc. v. United States, ASBCA 33770, 87-2 BCA (CCH) ¶ 19,916 (June 1, 1987).

Wallace L. Boldt, Inc. v. United States, ASBCA 27188, 84-1 BCA (CCH) ¶ 17,173 (Feb. 16, 1984).

Butt & Head, Inc. v. United States, ASBCA 26186, 84-1 BCA (CCH) ¶ 17,103 (Dec. 21, 1983).

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W. M. Schlosser Co., Inc. v. United States, VABCA 1802, 83-2 BCA (CCH) ¶ 16,630 (June 21, 1983).

Uribe Co. v. United States, AGBCA 80-114-1, 83-1 BCA (CCH) ¶ 16,199 (Dec. 17, 1982).

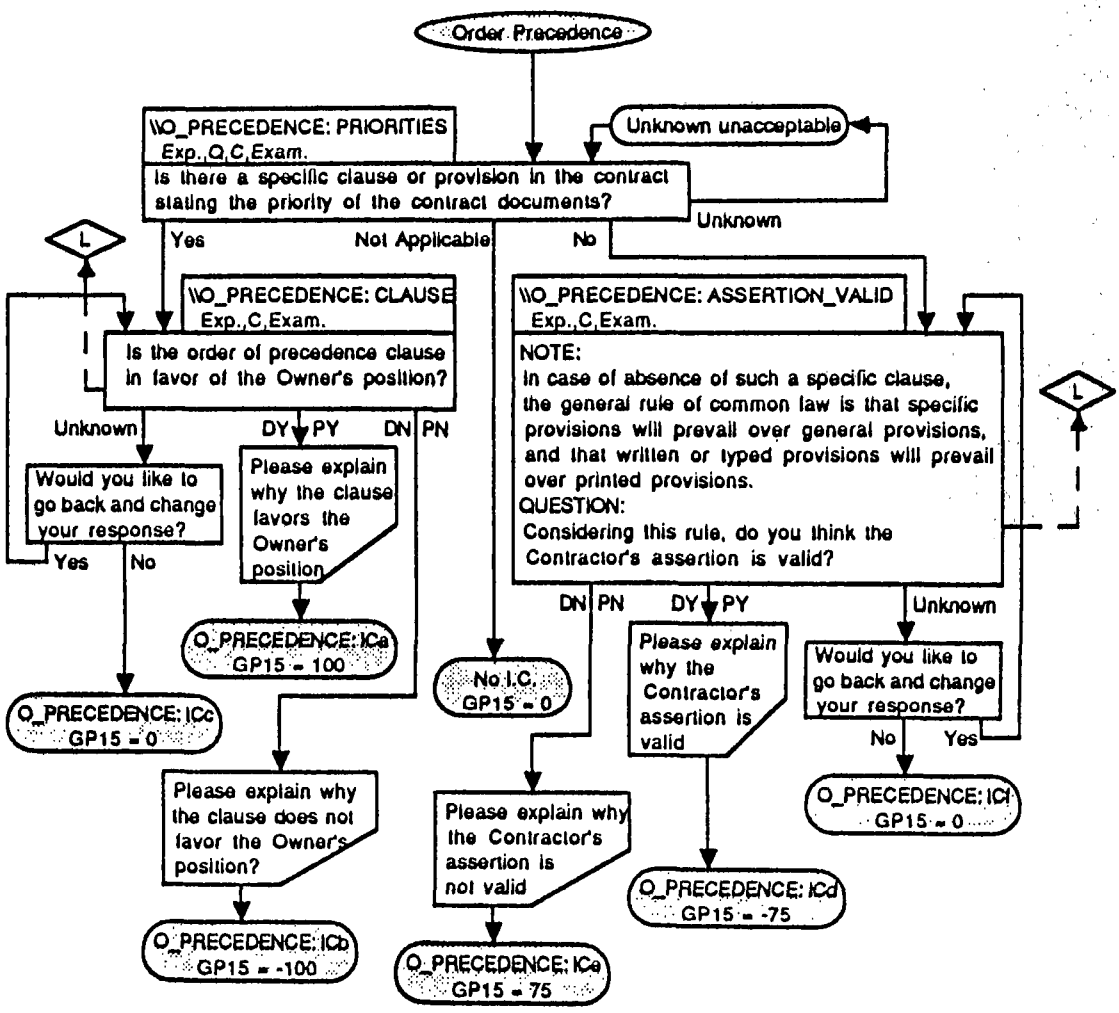

Figure 1. Sample Rule Group Tree

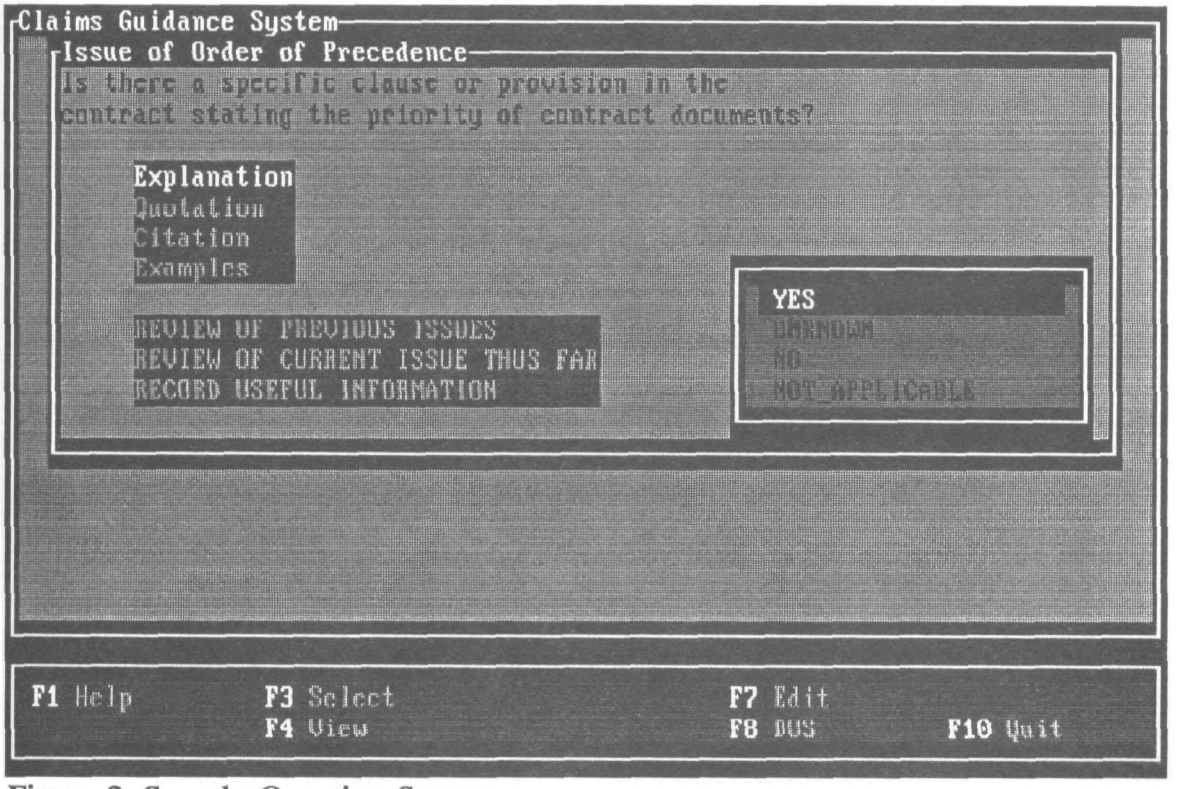

Figure 2. Sample Question Screen

GENERAL INFORMATION

Order of Precedence:

Contracts often will contain a clause which specifically delineates the priorities in the contract documents. Such a clause may, for example, state that anything typed in by the parties takes precedence over information on a preprinted form. In interpreting the contract, if two provisions conflict the order of precedence clause determines which interpretation the parties should follow.

In the absence of a specific order of precedence clause, the courts have developed several general rules. These general rules apply unless they are superseded by specific contract language:

1. Specific provisions prevail over general provisions;
2. Typed clauses prevail over hand printed clauses; and
3. Specifications have precedence over drawings.
4. Large scale drawings prevail over smaller scale drawings.

Figure 3. General Information Screen

ORDER OF PRECEDENCE

*** Is there a specific clause in the contract stating the priorities of contract documents or clauses?

Quotation

"A special provision noting the order of precedence of contract clauses takes over to express the contractual intent by specifically providing which of the two conflicting requirements shall take precedence and be effective." John A. Volpe Construction Co., VACAB 638, 68-1 BCA P6857 (1968).

Figure 4. Quotation Screen

ORDER OF PRECEDENCE

*** Is there a specific clause in the contract stating the priorities of contract documents or clauses?

Explanation

Owner contracts often contain specific provisions dealing with the order of precedence among the various portions of the contract should 2 or more clauses appear to be in direct conflict. The use of such a clause has the advantage of allowing for a mechanical resolution of a conflict. Such a clause may, for example, state that any requirements noted in the attachments to the contract provided by the parties take precedence over information in the specifications. In interpreting the contract, if two provisions conflict, the order of precedence clause determines which interpretation the parties should follow. If the contract contains such a clause it is binding on both parties.

If, however, the conflict is obvious or patent, the order of precedence clause may not be applied because the Contractor has an affirmative duty to clarify patent conflicts, errors and omissions with the Owner prior to submitting his bid.

Figure 5. Explanation Screen

ORDER OF PRECEDENCE

*** Is there a specific clause in the contract stating the priorities of contract documents or clauses?

Citation

Hensel Phelps Construction Co. v. U.S., CAFC No. 88-1545 (Decided September 29, 1989).
Edward R. Marden Corp. v. U.S., 803 F.2d 701 (Fed. Cir. 1986).
Franchi Construction Co. v. U.S., 609 F.2d 984 (1979).
De Palco, Inc., ASBCA 20630, 76-2 BCA P11,971 (1976).

Figure 6. Citation Screen

ORDER OF PRECEDENCE

*** Is there a specific clause in the contract stating the priorities of contract documents or clauses?

Example

FAR 52.214-29 (Jan 1986) provides a sample order of precedence clause: "Any inconsistency in this solicitation or contract shall be resolved by giving precedence in the following order: (a) the Schedule (excluding the specifications); (b) representations and other instructions; (c) contract clauses; (d) other documents, exhibits, and attachments; and (e) the specifications."

Figure 7. Example Screen

THE TUNNEL SYNDROME SOLUTION—CAN IT BE APPLIED TO CLEANUP PROJECTS?

(Author(s) and Addresse(s) at end of paper)

INTRODUCTION

Some innovative solutions unique to tunneling projects have recently achieved success in resolving disputes and reducing claims. The purpose of this paper is to suggest that there are similarities between hazardous waste cleanup and tunnel projects and that those solutions can be applied with equal success.

What are the most common causes of construction disputes? Consensus is that these are:

- Defective contract documents (i.e., errors and omissions)
- Unknown conditions
- Incompetent contract administration
- Incompetent contractor project management
- Interference of third parties

BACKGROUND

Up until the mid-1960s, the construction industry in the United States functioned as a triad working as a team. The owner established performance standards and criteria and retained design professionals to develop the basic concepts and design for the desired end product. The owner and the design professional acting as the owner's agent then engaged a general contractor to perform the physical construction in the field. Parties employed an experienced cadre of professional inspectors and craft supervisors. As problems arose, either with contract documents or unknown field conditions, a team effort was utilized to quickly solve the problem and devise an equitable contract adjustment within the terms of the contract.

Why have conditions changed? Three factors have greatly influenced the current construction contract environment. These are:

- The development of risk avoidance language for contract documents.
- The emergence of regulatory considerations wherein the scope and standards for the project are established by a third-party agency rather than the owner who controls the purse strings.
- With more emphasis on risk transfer, the emphasis has shifted to individual objectives and rights, all subject to disagreement and litigation.

DISCUSSION

Of all the risks facing both tunneling and hazardous waste cleanup projects, none is more significant than the ground itself, i.e., the unknown conditions.

The design professional needs information about conditions in the ground to design a product that will meet performance, cost and operational requirements of the owner (or of EPA regulatory standards). The contractor needs information in order to select crews, equipment, methods and sequence which will be the basis for his price quotation. Then there is a third factor which is that the ground may not behave as anticipated when the construction methods and means are applied. A. A. Mathews in his paper of October 1987, entitled "Special Contract Provisions for Reducing Construction Costs," summarized this phenomenon as follows:

> It is well known that the behavior of an underground structure is influenced by the construction method and the quality of its workmanship, as well as the design itself. Likewise, the construction method must be compatible with the geotechnical conditions to be encountered. There is, then, an ongoing and intimate relationship between the studies of the geotechnical engineer, the work of the designer, and the operations

> of the builder. While the designer must understand the geotechnical conditions which will affect his design, the design must be compatible with the methods which the contractor is likely to use.

In other words, the ground is the common adversary, and the solution is to join forces to defeat it. This concept of tunneling as a battle was first set forth by Gary S. Brierley in his paper entitled "Tunneling: A Battle Against the Ground":

> Successful tunneling is analogous to winning a battle. On the basis of almost 20 years of experience in the fields of geotechnical engineering and tunneling, the author has come to view the Ground as a tenacious adversary. Merely by doing what comes "naturally" when "provoked" by human beings, the Ground presents an array of defenses that make even good field commanders blanch at the prospect of battle.

Basically, what we are concerned about in this paper is how the owner approaches the issue of unknown conditions which result in changed conditions pertaining to the ground as the project proceeds. In this case, the owner could be a private party, a committee of contributors or sponsors, a state regulatory agency or a public agency. Before Differing Site Conditions and Changed Conditions clauses were incorporated into construction contracts, contractors working under fixed price or guaranteed maximum price contracts would include in their bids an amount to cover the cost of contingencies derived from unanticipated or unknown conditions at the site. Often these contingencies did not occur or did not incur in the amount anticipated. To avoid the increased costs that resulted from this practice, the use of a Differing Site Condition clause was instituted in federal contracts. Theoretically, this eliminated the need to include a contingency factor as the contract contained provisions for a price adjustment and a time extension.

In the process of design, the owner's team utilizes the services of a geotechnical engineer who develops data and often provides

interpretations. Traditionally, the design professional has viewed these reports strictly for the purpose of design and has provided the data to the contractor only because of the case law surrounding superior knowledge. Disclaimers are inserted, and there is often an attempt to transfer risk of the "ground" to the contractor. Just as often, this results in claims. (Refer to Figure 1.)

Even when Differing Site Condition clauses are used, disputes often result over the interpretation of what was "materially different" or what was a condition that was not to be anticipated at this particular site.

Disputes were a frequent result of these disclaimers and exculpatory clauses. A whole body of case law has evolved. In light of the fact that the owner and the design professional have months and years of "decision time" to obtain and analyze geotechnical data, while the contractor has usually about 30 to 45 days to put his bid together, courts tend to apply a "fair and reasonable" approach to give the contractor an equitable position. If the contractor uses the best available information and good judgment in selecting the crews, equipment, means and methods but then finds that the ground requires a change of crews and equipment at increased cost, the courts will often rule that this is prima facie evidence that a differing site condition has occurred. (Refer to Figure 2.)

This concept of the ground as the common enemy has led to the use in tunneling of some unique third-party dispute resolution processes built around a common geotechnical data base and a requirement that the contractor's bid documentation be available for dispute resolution purposes.

The dispute resolution alternative process now being used for tunneling consists of three elements.

- A Dispute Review Board which is formed at the time that the project starts and consists of a representative appointed by the contractor, a representative appointed by the owner and a neutral third party appointed by the other two.

- The concept of a single geotechnical design report used by both the design professional and the contractor and containing all information and opinions developed during the prebid phase.

- The concept of placing in escrow bid documentation to be used by the dispute review board.

If a contractor can demonstrate that the selection of crews, means and methods was reasonable and that a change in crews, means and methods is now required because of ground problems, this in itself may be proof of a changed condition. (See Figure 3.)

The Straight Creek Tunnel (now called the Eisenhower Tunnel) in Colorado is an excellent example of how this concept developed. The Eisenhower Tunnel crossing the Continental Divide at I-70 consists of two bores. The first bore containing two lanes of traffic had significant ground problems. The geotechnical information was probably the most extensive for any tunnel in the world. Investigation revealed that the claims arose not because different materials were encountered but because the ground behaved differently than expected, and thus the crews, means and methods selected by the contractor at bid time had to be changed. On the first bore upon receipt of a claim, the Colorado Highway Department made the decision that the material was as anticipated in the geotechnical reports; therefore, conditions were not changed. The argument revolved around the issue as to whether or not the material behaved as anticipated. By mid-1970, losses to the contractor had increased to the point where it could no longer continue normal operations without going bankrupt. The highway department had but two alternatives which were to negotiate an addendum to the existing contract or declare

the contractor in default and attempt to have the bonding companies take over the job.

Wisely, the highway department decided to settle the claim for an additional amount of $5 million with future tunnel work to be paid on a time-and-material basis. The highway department never would admit that a differing site condition had been encountered.

Bidding and construction for the second bore was approached in an entirely different manner utilizing the concepts discussed above. A Dispute Review Board was established. Bid documentation was placed in escrow to be examined at any time by the Chief Engineer of the state highway department to determine the contractor's bid concept. Rather than bid as a lump sum plus profit, costs were bid as a unit price plus a fixed fee. All disputes on the second bore were satisfactorily resolved.

Starting with the Eisenhower Tunnel second bore in 1975, the disputes review board concept has been utilized on a number of major construction projects, most notably in the underground construction field. To date, 12 completed contracts and 21 contracts under construction employ this approach. Most importantly, where disputes review boards are employed, there has been no litigation. Currently, disputes review boards are planned for 26 future projects in the underground construction area alone, primarily tunneling.

The other two elements of the process, the geotechnical design summary report and the escrowed documents, are more controversial yet are important elements of the process.

The concept of a complete Geotechnical Summary Report for use by both the designers and the contractor was first presented as early as 1974.

"Better Contracting for Underground Construction," National Committee on Tunneling Technology, National Technical Information Service, November 1974

. . .

DISCLOSURE OF ALL SUBSURFACE INFORMATION, PROFESSIONAL INTERPRETATIONS, AND DESIGN CONSIDERATIONS

Owners, engineers, and contractors agree that adequate and timely subsurface study of the facility site is necessary. . . . Difficulties also arise from the failure to make the data and interpretation thereof available to those people interested in bidding on the work.

. . . Although engineers consider that where time and money are available, subsurface information adequate for design purposes is obtained, contractors maintain that sufficient information on subsurface conditions to eliminate contingencies from their bids is never provided. Information that is considered to be basic data includes such items as the following:

- Rock cores or soil samples recovered and photographs of these.

- Water-level measurements, including times, dates, and correlation with drilling operations.

- Method and equipment used in sampling.

- Observations made during drilling with respect to drilling rate, drill-water conditions, bit pressure, and rotational speed.

- Field-test data, e.g., pump or packer tests, records of geophysical down-the-hole tests, deformation and strength tests.

- Field or laboratory test results on specimens, including petrographic examinations.

- Certain measurable items in the core log, including sample depths and core recovery.

- Identification and description of lithological and structural units as found in outcrops and rock cores or soil samples.

- Assessments of characteristics of discontinuities such as planeness, roughness, coatings, filling material, and leaching.

Other subsurface information, although not in the same category as geologic data, is quite as basic to the contractor's need-to-know. Knowledge of the exact location and condition of existing substructures and utilities is an important prerequisite to design of the project and just as important in the development by the contractor of the method of constructing the project as designed.

Opinions of qualified professionals regarding the characteristics of the subsurface are rarely given to prospective bidders, in the belief that such disclosures will only promote the subsequent submission of claims by the successful contractors. Whether or not this is true, if interpretative reports were obtained they must be revealed in the event of litigation. Therefore, prospective bidders should receive these reports. The more information they receive, the more accurately they can evaluate the job. . . . If adverse conditions, not apparent from the basic data, were foreseen by the owner's geologist, these should be disclosed prior to bidding and not during the course of costly litigation. . . .

Geotechnical interpretation involves geological assessments of geophysical exploration, assessments of soil or rock characteristics such as relative strengths, hardness, induration, and degree of weathering or alteration, geological maps and sections, soil profiles, and all recommendations and comments pertaining to the design and construction of the works based on examination of the factual data.

It is not customary for design engineers to reveal their professional judgments in formulating a design; however, if the geotechnical report has a significant effect on the design, then this information should also be revealed.

In sum, all subsurface data obtained for a project, professional interpretations thereof, and the design considerations based on these data and interpretations should be included in the bidding documents or otherwise made readily available to prospective contractors. Fact and opinion should be clearly separated. . . .

Some disclaimer is still appropriate pertaining to interpretation and opinion. The report referred to above recommends:

. . .

- Information obtained by others, perhaps at other times and for other purposes, which is being furnished prospective bidders in order to comply with the legal obligation to make full disclosure of all available data.

- Interpretations and opinions drawn from basic subsurface data, because equally competent professionals may reasonably draw different interpretations from the same basic data.

Information, interpretations, and opinions, such as described above, should be specifically identified as such and differentiated from the basic subsurface data being furnished. Further, if disclaimer is made of responsibility for accuracy, then notice should be given that such information, interpretations, and opinions are not included as a part of the contract. Bidders will then be in a position to evaluate them and price their bids accordingly.

CONCLUSION

The escrow document concept is even more controversial. Nevertheless, it has been used with great success on a number of tunnel projects. It is based upon the concept of an equitable adjustment wherein the contractor is to stay "whole," that is, in the same position as if no problems had occurred. (Refer to Figure 3.) If all parties accept that the ground is the common enemy, then the contractor's bid documentation should reflect how the contractor interpreted the available information in his selection of crews, equipment, methods and the risk leading to profit. The bid documentation in escrow provides a basis for keeping the contractor "whole." Escrowed bid documentation should assist the disputes review board in arriving at an equitable adjustment.

The concept of the disputes review board in place from the beginning of the project integrated with escrowed bid documents and a geotechnical summary report should be considered for hazardous waste cleanup as a means of avoiding or settling disputes and facilitating the progress of this important program.

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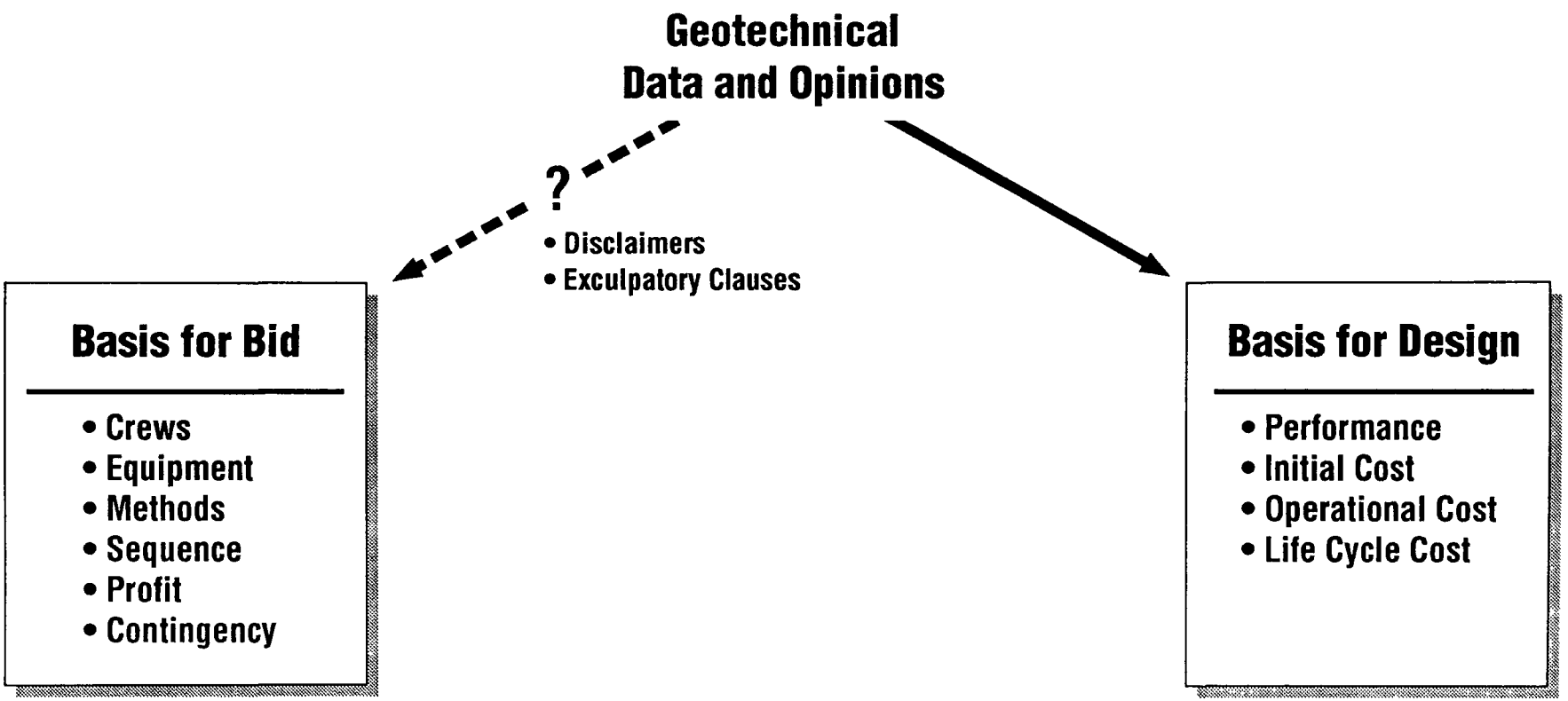
Figure 1

The Ground
Basis for Bid vs. Basis for Design



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KELLOGG

Figure 2

The Common Enemy

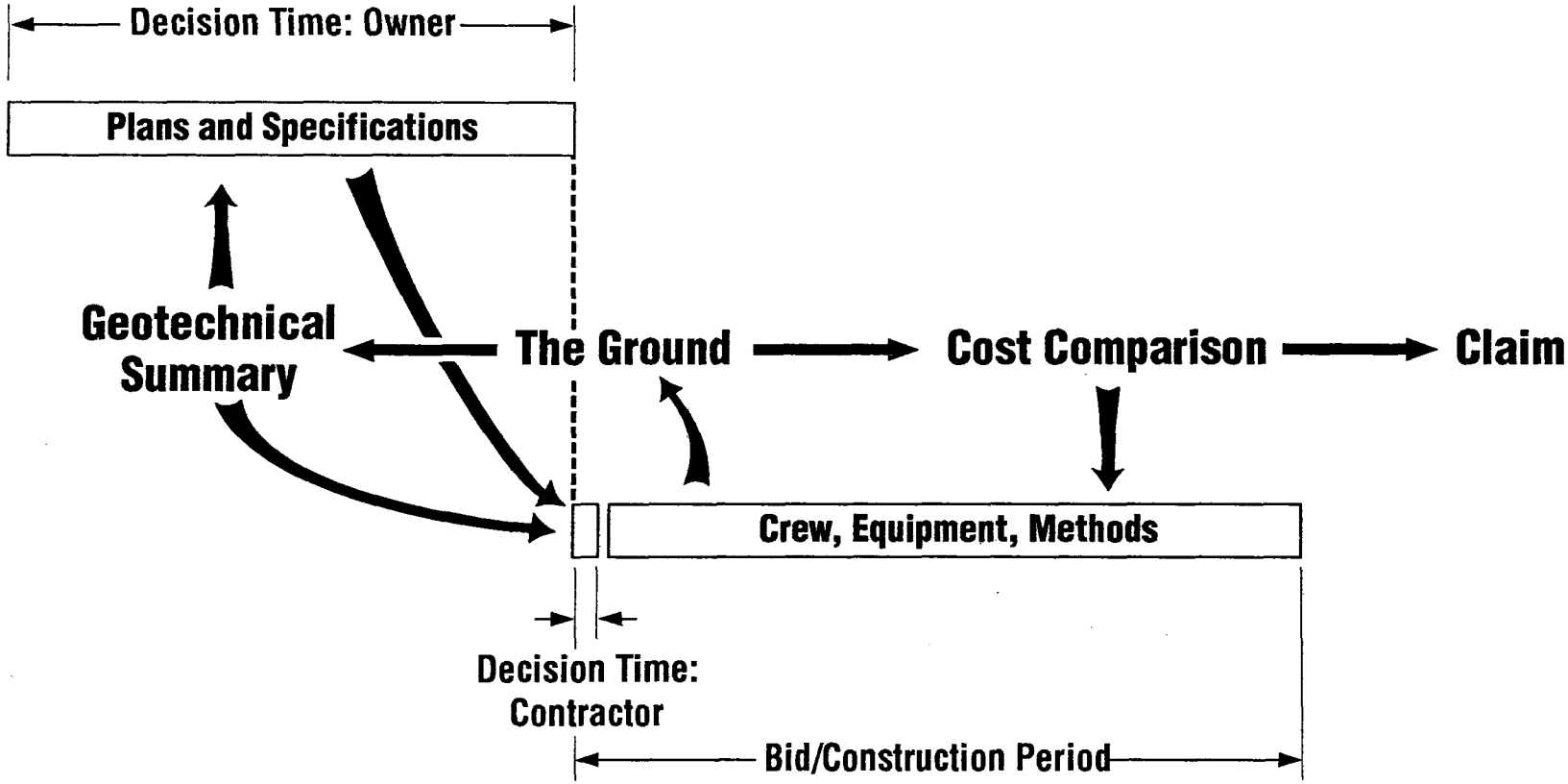

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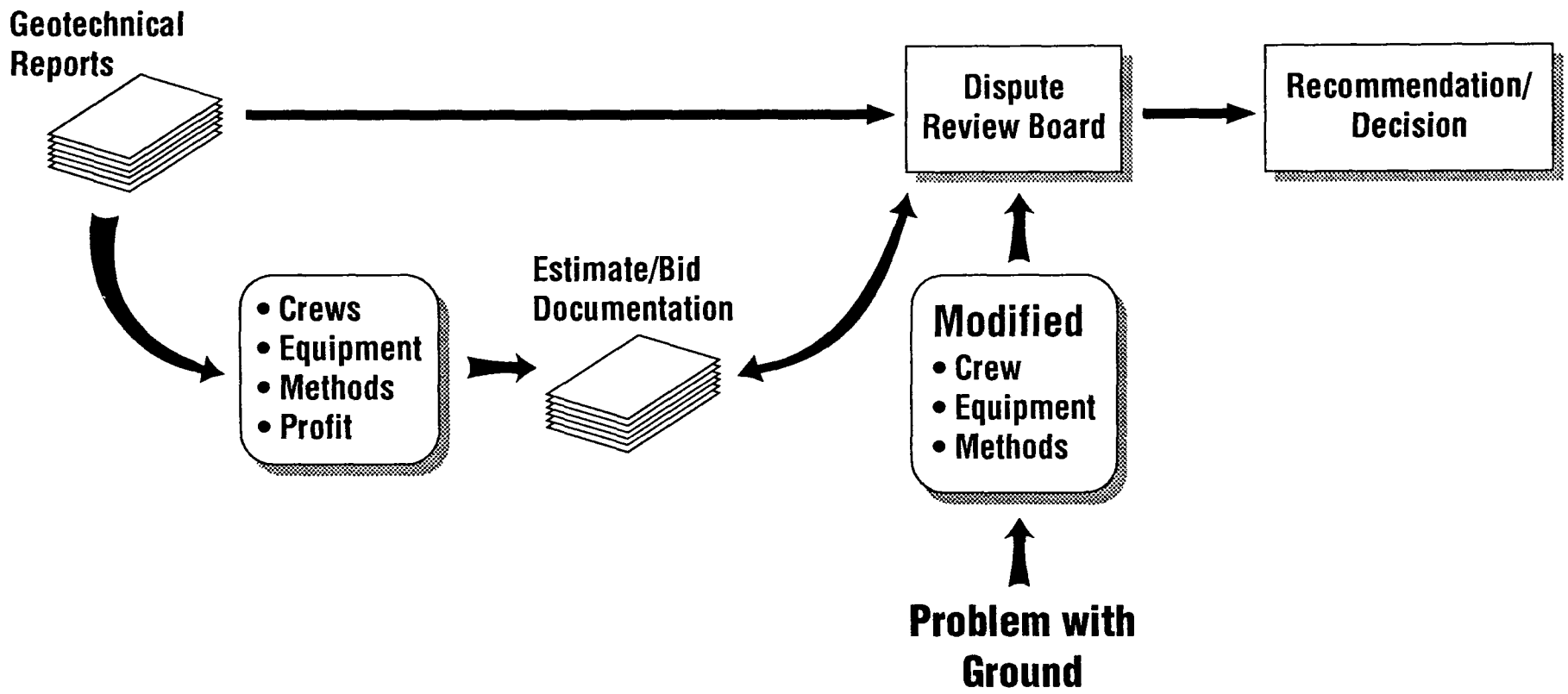
Figure 3

Staying "Whole"



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KELLOGG

The First Step for Strategic Environmental Project Management: Environmental Cleanup Project Contract

(Author(s) and Addresse(s) at end of paper)

1) INTRODUCTION

A complex threat to the world's population has emerged since the demise of the cold war, namely, the destruction of the earth's environment. It has been estimated that in the near future, the industrialized nations of the world will need to spend 2.5% of their gross national product on programs designed to repair the environment. Environmental cleanup construction projects are extremely costly and highly visible to the public. Resources available to pay for these clean-up projects are increasingly difficult to find. Because once strained international relationships have become friendly, policy makers foresee a decline in defense spending. This decline will create federal funds not previously available, and according to Senator Sam Nunn, Chairman of Senate' Armed Forces Committee, the funds should be earmarked for the restoration of the environment. Because a comprehensive construction management plan for environmental cleanup projects has never been developed, the Department of Defense (DOD), the Department of Energy (DOE), and the Environmental Protection Agency (EPA) have a clear and immediate interest in developing better technologies for cost-effective methods of identifying, treating, and cleaning up sites containing toxic, radioactive, and hazardous materials. EPA and DOE district officers have also expressed an urgent need for radioactive and hazardous by-product cleanup guidelines. Research in this area will coordinate the development of these cleanup efforts, ensuring that these toxins to the environment are handled with the utmost efficiency. (7)

In June, Senator Nunn proposed the creation of a Strategic Environmental Research Program to be administered by a new Defense Environmental Research Council. "Understanding what we are doing to the environment today, cleaning up the damage we have done in the past, and modernizing U.S. industries and government to establish and maintain technological leadership in this critical area in the future," are the newest goals for policy makers.(9) Nunn believes that environmental technology will be the growth industry of the

next 20 years. Because forms of environmental destruction such as global warming, deforestation and rapidly increasing atmospheric concentrations of gases could exacerbate ethnic or regional conflicts, Nunn says it is imperative for the U.S., especially the defense establishment, to marshal a global response to these problems by developing the technology to clean up our environment. This development will also help DOD and DOE meet their environmental cleanup and treatment obligations more quickly, efficiently and at a lower overall cost.

2) SIGNIFICANCE OF RESEARCH

2.1 Historical Background: The year 1990 was the 10th year since the passage of the Comprehensive Environmental Response, Compensation and Liability Act - the landmark legislation that launched Superfund. The decision by Congress on November 1990 to reauthorize Superfund virtually intact through 1995 will likely give the program the opportunity to move forward unencumbered by the rancor and stalemate that characterized its last reauthorization in 1985-86. (5)

One of the most controversial aspects of the Superfund makeover in term of construction management is its approach to assessing construction riskiness and setting construction standards. For example, EPA should identify a construction's risks, set cleanup objectives based on those risks, on the perspective future of the site and on citizens' concerns, and then select a construction standard from those among those alternatives that meet the standards.

Another area of controversy is a lack of standard construction guidance. It has been very confusing and hard for the construction industry to work in the environmental cleanup construction projects since practices on design and construction differed markedly from region to region. At the recent Superfund conference in Washington, D.C., the private sector construction industry clearly indicated that they would see more liability issues on federal led

cleanup projects unless they are provided the standard technical guidance in taking over construction risk assessments for all Superfund sites. (11) Contractors and engineers are also concerned about the ability to which the standard technical guidance provide the useful data-base on new innovative construction methodology.

EPA Deputy Administrator told Superfund attendees that the program remains beset by regulatory glitches, a lack of standard construction guidance and "cultural" impediments such as liability and risk aversion. "We hope that by moving on first two, we can have an impact on the third," he said. (6)

2.2 Current Construction Practices: The United States has led the world in the technological advancements made in construction management (CM) over the last thirty years. Despite infrastructure construction capabilities that surpass those of any other countries, the construction management strategies for environmental cleanup projects are severely underdeveloped. Groundwater barriers, surface seals/caps, solidification and stabilization methods have been developed from general construction practices, but these also suffer from a lack of sufficient long-term study. The environmental construction segment of the industry is notorious for it's lack of consistent project management guidance and lack of qualified supervision. There are very few construction companies that have attempted to build structures to aid in the cleanup of the environment. Consequently waste treatment plants, landfill sites, water treatment plants, radioactive waste disposal sites, water reservoirs, and structures that prevent soil erosion present unique problems for environmental protection managers. These problems are compounded by high risks, fluctuations in federal regulations and post-construction liability, all resulting in wary, medium-size construction businesses that avoid environmental construction altogether. (16)

There is uncertainty in the assessment of problems and uncertainty in the solutions. Conventional methods are used

currently in cleanup sites, but this has created a patch-work of inconsistent methods, increased confusion and has only provided the nation with a temporary solution for problems that last for centuries. Non-conventional construction methods, non-guided quality control systems, construction sites that are widely spread out, and non-guided life-cycle activities have inhibited the natural development of project management systems and the testing of many different environmental construction projects.

The construction management system for environmental cleanup projects differ fundamentally from conventional facilities projects, creating a multitude of problems not found in conventional construction areas. The difficulties of managing such projects are compounded by a lack of well-documented guidance and by procedural requirements imposed by the government agencies involved. By integrating environmental construction needs with infrastructure experience, better applications can be developed to address the environmental problems facing the industrialized world. With clear goals and objectives, the construction industry, policy makers and researchers can insure that the United State's environmental remediation construction capabilities will be on the cutting edge of technology. This research is significant because we need cost-effective construction management alternatives to plan, execute and operate/maintain environmental remediation construction projects.

2.3 Overall Objectives: The overall objective of this research is to develop a **Strategic Environmental Project Management (SEPM)** system. This is the first step towards establishing an integrated environmental construction management system, designed specifically for the contaminated site cleanup projects. There are two primary objectives to this research.

The first, which is a prerequisite to the second, is to acquire detailed information about the formation and characteristics specific to environmental cleanup construction projects. The SEPM system has an "Integration" feature to address the

legal/contractual and financial/cost considerations as they impact the technical requirements for a SEPM system. Design, engineering, construction, operation, and maintenance activities will also be defined during the explanation of technical procedures for the SEPM system. Upon review by appropriate federal agencies and private contractors, the manual version of SEPM system, Draft Technical Guidance (DTG), will be produced in the designated format at the end of first phase.

The objective of the second phase is to integrate and implement the results of the first phase into the computerized SEPM systems. The computerized SEPM system will also have the features of database and decision support analysis to provide advisory assistance for each component of the SEPM system. Those features will support the management of environmental cleanup construction projects and decision-making by providing lessons-learned and advisory information based on similar experience with projects. (12) Personnel without extensive first-hand experience in a particular environmental construction project will benefit from the expertise provided through examples from the SEPM system. The breakdown of detailed research activities is shown in Figure 1.

2.4 Current Objectives: The objective of the current research is to develop a **Environmental Cleanup Project Contract (ECPC)** system, the first step towards technical requirements for a SEPM system, designed specifically for the contaminated site cleanup projects. A brief description of the process and of our developmental work for the ECPC system are shown in the Appendix 1.

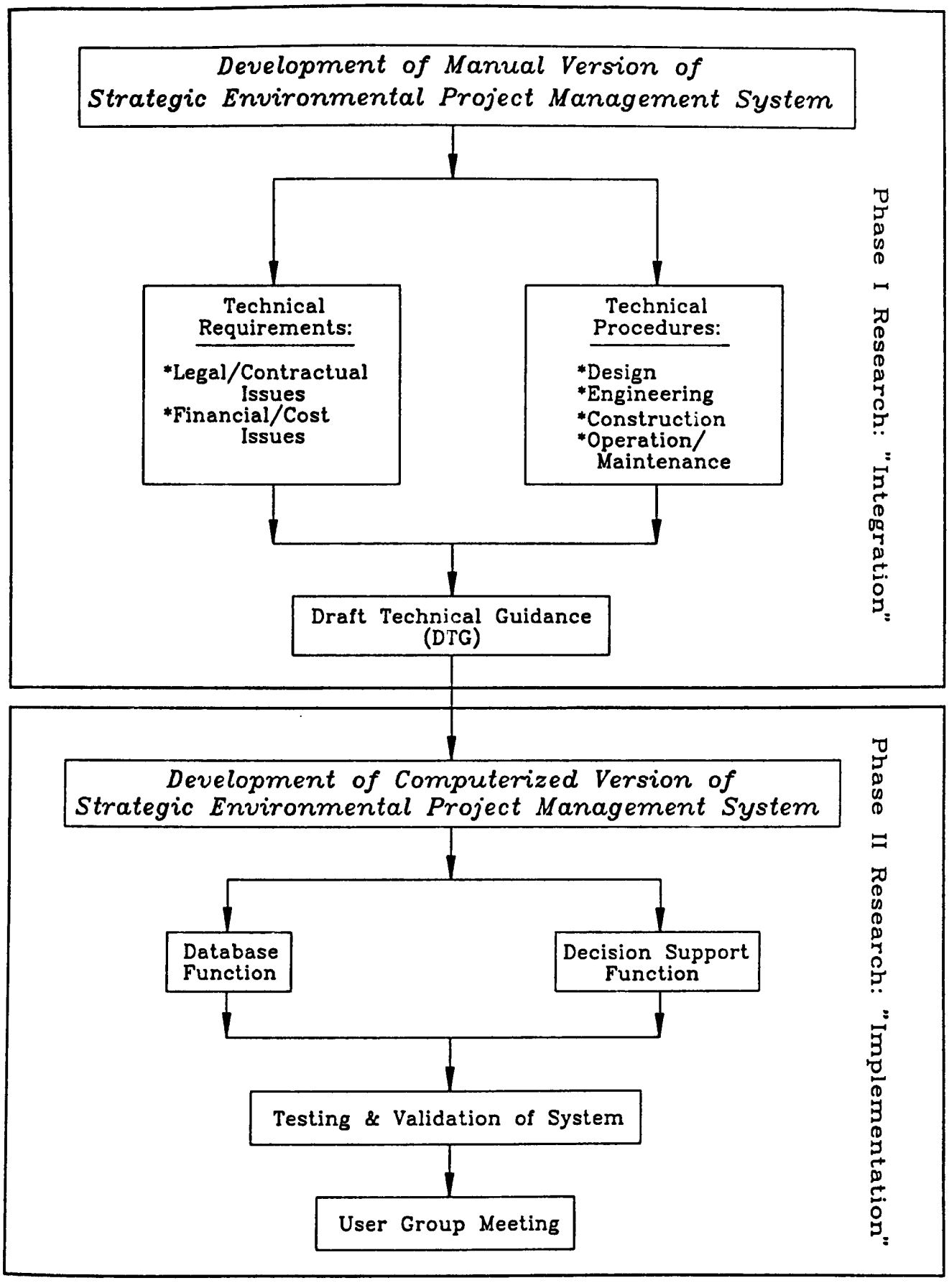

Figure 1. The Breakdown of Research Activites

3) SCOPE OF RESEARCH

3.1 Phase I Research Activities

a. **Review current and recent environmental cleanup construction projects:** These include contaminated site clean-up projects. Data and information will be obtained relative to the general service provided under the projects, such as feasibility study, development considerations, execution of the projects, procurement experiences, facility requirement, and performance of the facilities in service. Federal environmental procurement personnel and their counterpart, private developing and design-build-engineering contractors will be consulted.

b. **Identify Technical Requirements:** Two key parameters will be studied for the technical requirement of SEPM system. First, in legal/contractual issues, considerations and parameters for the scope of services included in contracts will be identified. Responsibilities of the involved parties, contract duration, basis for contractor selection, contract enforcement provisions, facility ownership, disposition of the facility at the conclusion of the contract, and other relevant legal contractual issues will also be covered in this issue. Second, in cost/financial issues, economic analysis and feasibility, construction accounting, construction insurance handing liability change, costs and investment, and construction financial arrangement will be examined as they impact a project's requirements and execution. Information will be obtained through contact with the involved federal agencies and user group meetings.

c. **Identify Technical Procedures:** Based on the identified technical requirements, the content and composition of technical procedures for environmental cleanup construction projects will be identified. This includes the identification of the appropriate sources for design, engineering and

construction criteria and the composition of technical requirements for a SEPM solicitation document. This also includes initial project planning activities, solicitation requirements and procedures, contractor selection criteria and procedures, design/construction administration, and conditions for the operation and maintenance of environmental construction projects.

d. **Produce a Draft Technical Guidance (DTG):** Upon review by the appropriate federal agencies and private contractors, the DTG for the SEPM system will be produced in the designated format. The DTG system documentation shall provide a complete functional description, system schematic, and unique features of the environmental cleanup construction project.

3.2 Phase II Research Activities

a. **Computerize a Draft Technical Guidance:** Integrate and implement the Draft Technical Guidance into a PC-based computerized system. Specific computer software such as HYPERMEDIA will be used in the computerized process of the Draft Technical Guidance.

b. **Add Database and Decision Support Functions:** The two key features functions will be added to the SEPM system to support the management of environmental cleanup construction projects and the decision-making by providing lessons learned and advisory information based on similar environmental project experience. First, the objective in providing the database function is to translate data and resources through a series of data generation, information gathering, information processing, and physical realization cycles. Typically, the construction database will be used by designers, architects, contractors, and maintenance personnel. Each of them would address different questions. However, they may have a common

shared database. It becomes imperative that the system be able to identify the user and defines intelligently the query. Table 1 gives clearer view of the database scheme. At each level it is obvious that the level of details and requirements would be different. Second, the process models highlight the specific nature of the decisions, feedbacks, and information required to support the SEPM system. While each of these decisions is made by different groups with unique experience, using information and rules that seem radically different from each other, there are many similarities. Specific decision support requirements will be added in the SEPM system as follows: (13)

1. Retrieve a single item of information,
2. Provide a mechanism for ad hoc data analysis,
3. Aggregate prespecified data,
4. Estimate the consequences of proposed decisions,
5. Propose decisions,
6. Implementation of decision,
7. Monitoring decision.

c. **Conduct Testing and Validation of SEPM system:** Due to the fiscal and legal implications of the SEPM system it must be very thoroughly tested. The DTG system documentation shall be reviewed by professional engineers and contractors in the area of environmental cleanup construction project. Suggestions shall be solicited for modifications to the system, and all noted errors and deficiencies will be corrected.

d. **Conduct User Group Meeting:** Input from knowledgeable persons from the targeted user communities such as in the Environmental Protection Agency (EPA) and US Army Corps of Engineers (USACE) shall be solicited. Their comments and suggestions shall be requested concerning the utility and completeness of the system, needed improvements in the user interface, and DTG system documentation.

Table 1. Database considerations for the SEPM system

Question	Design activities	Source	Resultant
1	Identification of pieces of data	Process model	Individual identification
2	Attribute identification	Process model	Qualitative description
3	Entity set	Process model	Grouping of objects
4	Use of entity set	Process model + grouping	Uses vs classification
5	Users of information	Site interview + published literature	Users view of information system
6	Identification of user's query	Process models + site interview	General and specific queries
7	Feedback consideration	Process model + queries	User interaction requirements
8	Updating process	Resultant of previous seven stages	Updating and integrity procedures

d. **Conduct User Group Meeting:** Input from knowledgeable persons from the targeted user communities such as in the Environmental Protection Agency (EPA) and US Army Corps of Engineers (USACE) shall be solicited. Their comments and suggestions shall be requested concerning the utility and completeness of the system, needed improvements in the user interface, and DTG system documentation.

4) FUTURE RESEARCH

Through the proposed research, the principal investigator plans to establish a platform for future investigations in life-cycled project management system for environmental cleanup construction project. The development of the SEPM system has been recognized as the first step towards the goal of a life-cycled project management system at a recent symposium for concerning

federal infrastructure and environmental cleanup projects.(10) In addition, the basic framework developed in this work will be an important tool in related area of interest to the principal investigator. This interest includes study of the development of an Unified Project Model for Design/Engineering/ Construction to represent environmental construction project data in real-time. The common theme for all this work is the improvement of the state of construction engineering practice by increasing our capability to realistically analyze, construct, and manage environmental cleanup construction projects.

Future research will develop a **Life-Cycle Project Management (LCPM)** system to improve the integrated cost, schedule, and quality management of environmental cleanup construction projects by applying innovative productivity methods, assuring completion within time and budget, and enhancing the quality of the construction project. As described previously, the basic framework for construction management strategies will be developed such that it can be easily extended to include the interaction of more models than will be included in the current study of SEPM model.

The intelligent cost and schedule control models will be modified from traditional techniques in order to meet the unique nature of environmental cleanup projects. An intelligent risk management model will be developed and incorporated into the integrated environmental LCPM model.

Further work is also envisioned to develop an innovative application model for robotics, remote sensors, and other innovative non-human technologies will also be developed and linked to the risk management model and the integrated LCPM model. Also innovative contract and quality control models have the potential to be included for the integrated environmental LCPM model.

The current phase of research is an essential first step for more advanced studies. By stydying the construction management strategies for environmental cleanup construction projects, the current work will help focus the direction of future research.

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APPENDIX I

Today more than ever there is a great national push for better and more efficient use of the ten year old Superfund that was supposed to solve environmental cleanup problems. As much as the larger consturction contractors would like to be involved in environmental concerns, they still believe that the timing is not right. Much of this can be blamed on the risk factor, and confusion due to inexperience with complex environmental cleanup projects.

One major problem with environmental cleanup projects is a confusion about the contractual/legal dealings between the government and the contractor. With today's laws, the contractor assumes much of the risk involved in cleanup projects. Contractors may be liable for current projects even ten years from now. This is normal for typical building or roads contracts, but because the environmental cleanup industry is still in the embryotic stages of development, contractors do not want to be held responsible for untried practices.

In order to get more contractors involved, the proper type of contract should be developed to explain the mechanism of risk-sharing and to provide clauses for contractual indemnity. We in the Center for Infrastructure Research (CIR) at the University of Nebraska-Lincoln, are currently in developing a contract outline that can be structured to environmental cleanup projects that satisfy the contractor's need for risk-sharing and indemnity. The Design-Build type of contract was based on the Environmental Cleanup Project Contract (ECPC), allowing the contractor to use creative design/engineering/construction practices deemed best for specific situations under government scrutiny. This ECPC will also assure the owners and government that the contractor is competent and will not try to cut corners. Another main emphasis has been on the creation of a communication channel between the contractor and the owner/funder for every phase of construction process.

Communication has been identifited as an important area of improvement due to the unclear nature of design/engineering/ construction cleanup practices which are subject to change in unexpected circumstances.

On the following page is the Environmental Cleanup Project Contract (ECPC) which is a standard form for a Design-Build agreement for cleanup projects between the contractor and the project owner/funder. This is the skeleton of an ECPC and does not attempt to actually cover all issues of the agreement process. Its standardization, however, makes for easily read scope of what has to be accomplished between the owner/funder and the contractor. With the ECPC the contractor and the owner/funder have a form of agreement that allows the contractor a greater amount of freedom, while giving the owner/funder the assurance that work will be conducted in a safe and professional manner.

E C P C

Environmental Cleanup Project Contract

Section 1

This section involves the agreement. It defines:

A) The organization of the construction team - contractor with design/engineering capabilities and the project owner/funder.
B) The environmental site assessment.
C) The description of construction work - what the construction team is to accomplish.
D) The safety requirements and responsibilities.
E) The agreement between parties.

Section 2

This section explains the contractors responsibilities. It defines:

A) Contractors services (what is to be done).
B) Contractors abilities and qualifications.
C) Contractors responsibilities during construction.
D) Contractors additional services.

Section 3

This section defines the owner/funder responsibilities. It defines:

A) Responsibilities to the Contractor.
B) Long term responsibilities of the site.

Section 4

This section defines responsibilities and qualifications of all subcontractors and material suppliers.

Section 5

Details about the contract time schedule are included in this section. It defines:

A) Substantial completion.
B) Extensions of work

Section 6

This section deals with project payment. It is recommended that with the Design-Build type contract a cost plus fixed fee type of payment should be considered. Not only does this insure payment to the contractor but also will maintain the best quality of work which is so very important for such circumstances.

Section 7

This section deals with changes incurred on the projects.

A) Change orders.
B) Emergencies - common only to hazardous waste.

Section 8

This section includes risk sharing. It defines:

A) Insurance - must be made more available to contractor.

B) Liabilities - mechanism/formula of risk shar-

ing between the parties.

C) Indemnity.

Section 9

This section deals with termination of agreement.

A) Termination rights of contractor.

B) Termination rights of project owner/funder.

Section 10

Laws for agreement. Enables government to enforce critical contracts that may endanger life. Also includes typical laws more common to construction contracts.

Section 11

This section explains the important design/engineering/construction principles. It defines:

A) Arbitration board and mini-trial procedures through the process of a court trial. Establishing the communication channel is essential for the ECPC to work in an environmental cleanup construction project and quick dispute settlement process.

B) Constructability issues

C) Value engineering issues.

Section 12

Miscellaneous provisions. Self explanatory.

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INTRODUCTION

Local governments have a legitimate need to assure that activities conducted within their borders do not jeopardize the public health or welfare. Uncontrolled construction activities can damage or disrupt utilities, hinder traffic, impede fire or police services and restrict the local government's delivery of essential services. Construction activities may also create threatening or dangerous situations. Most local governments utilize a system of permits to protect their infrastructure from damage or undue disruption.

Superfund-financed remedial actions are exempt from Federal, State, and local permits for the portion of work conducted on-site. As a result, project managers often view obtaining permits as unnecessarily burdensome and time-consuming. Yet, circumstances may warrant the efforts needed to obtain permits for on-site as well as off-site actions. These permits will, for example, assure EPA that the adverse effects to local communities of its activities are minimized. Also, the permitting process itself creates a systematic method for coordinating with local governments and agencies. However, this process requires significant advance planning as well as substantial resources to avoid project delays.

Ideally, obtaining permits is straightforward and progresses smoothly. At its worst, permitting turns into a quagmire of unexpected requirements, delays, and budget overruns. At the Hollingsworth Solderless Terminal Company site, the EPA and its contractors expended extraordinary effort to permit a relatively simple remedial action. This paper reveals the permitting nightmare we encountered, provides insights into the process and identifies some potential pitfalls. The experience gained during the ordeal may prove useful in avoiding permitting problems at other sites.

BACKGROUND

The Hollingsworth Solderless Terminal Company (Hollingsworth) site is located at 700 NW 57th Place in the City of Fort Lauderdale, Broward County, Florida. The site encompasses approximately 3.5 acres. The Hollingsworth facility consists of two buildings separated by a public street. The entire facility is bounded by asphalt alleyways, a second public street, and other industrial properties.

Land use in the vicinity of the Hollingsworth site is a mix between commercial, industrial, and residential. The area immediately surrounding the site has a high density of medium and light industry. The Fort Lauderdale Executive Airport, Seaboard Coastline Railroad, and Interstate 95 (I-95) are nearby. Beyond I-95 to the east is a large residential community.

The City of Fort Lauderdale's primary water supply, the Prospect Well Field, is approximately two miles west of the site. This well field includes 38 functional wells located around the Fort Lauderdale Executive Airport and Prospect Lake. The wells closest to Hollingsworth are within a quarter to a half mile.

The primary source of drinking water for three million residents of South Florida is the Biscayne Aquifer. This highly permeable, unconfined aquifer is composed of limestone and sandstone and underlies the site. Both the Executive Airport and Prospect Lake wells tap the Biscayne Aquifer for water supply. In the area of the site, the top of the aquifer is near the natural ground surface, and its base is approximately 250 feet deep. The upper 60 to 70 feet of the aquifer are primarily composed of fine to medium grained sands. This zone is underlain by a transition zone of cemented shell and sandstone and finally by the limestone which forms the major water producing zone of the Biscayne Aquifer. The regional direction of ground water flow is southeast.

The Atlantic Ocean is located approximately five miles to the east of the site and the Everglades lie about 10 miles to the west. The average rainfall for this area is approximately 70 inches per year. The site is located within the 100 year flood plain and is topographically flat.

From 1968 until 1982, Hollingsworth was in the business of manufacturing solderless electrical terminals, consisting of a conductive metal portion and a plastic sleeve. The terminals attached by means of crimping rather than by soldering. The manufacturing process included heat treatment in molten salt baths, degreasing, and electroplating.

For approximately eight years, Hollingsworth disposed of wash water and process wastewater contaminated with trichloroethene (TCE) into drain fields adjacent to the manufacturing plant and into an injection well onsite. These disposal practices contaminated the soil and groundwater. The primary contaminants of concern at the site are TCE, vinyl chloride, trans-1,2-dichloroethene, and cis-1,2-dichloroethene.

As early as 1977, the Broward County Environmental Quality Control Board and the Florida Department of Environmental Regulation (FDER) were concerned with the environmental status of the site. These agencies requested EPA assistance in 1981. The EPA included the site on the first official National Priorities List published in 1982, and, in the same year, commissioned a Remedial Action Master Plan. The Potentially Responsible Party, Hollingsworth, initiated Remedial Investigation activities in 1983, after filing Chapter 11 Bankruptcy. The EPA subsequently conducted the Feasibility Study and issued a Record of Decision in 1986. The EPA completed the Remedial

Design in 1988 under the REM II Program. In 1989, under the REM III Program, Ebasco Services Incorporated (Ebasco) received the work assignment to implement the fund-lead remedial action. The EPA later transferred this work assignment to ARCS IV.

DISCUSSION

The remedial design, finalized in 1988, prescribes in-situ treatment of soil; and extraction, on-site treatment, and injection of groundwater. The aspects of the design related to the permitting issues include:

(1) Installation of three wells to extract contaminated groundwater from the aquifer,

(2) Construction of two stripping towers to remove the volatile contaminants, and

(3) Installation of two wells to return the treated water to the aquifer.

The estimated duration of water treatment is nine months at a design rate of 450 gallons per minute. The design specifies remediation of TCE- contaminated soil by in-situ vacuum extraction or an alternate approved method.

The design also specifies above-ground vaults for housing the extraction well pump motor control panels, valves, and pressure gauges. These vaults, approximately six feet long, three feet wide, and two feet deep were to be located at the extraction wells and were to be surrounded by protective pipe bollards.

Several components of the water treatment system are located in the public alleyways surrounding the site. These components include two of the three extraction wells and associated above-ground vaults, both injection wells and a majority of the interconnecting underground piping. The third extraction well and its above-ground vault, both stripping towers, the construction office trailer, the construction laydown area and the soil treatment area are all located on Hollingsworth property. The stripping tower, construction office trailer, soil treatment and construction laydown areas are fenced.

Ebasco procured a remedial action subcontractor to construct and operate the required treatment systems. In December 1989, Ebasco issued the Notice to Proceed to its subcontractor, Westinghouse HAZTECH, Inc. (HAZTECH). The subcontract specified that HAZTECH was responsible for securing all necessary permits. By early January, Ebasco and HAZTECH had identified the permits and discussed the associated schedules for obtaining them.

The identified permits and the issuing agencies were:

	Permit	Issuing Agency
1.	Building	City of Fort Lauderdale
2.	Electrical	City of Fort Lauderdale
3.	Fencing	City of Fort Lauderdale
4.	Temporary Traffic Modification	City of Fort Lauderdale
5.	Right-of-way Construction	City of Fort Lauderdale
6.	Extraction Well Construction	South Florida Water Management District
7.	Extraction Well Water Use	South Florida Water Management District
8.	Injection Well Construction	Florida Department of Environmental Regulation
9.	Injection Well Use	Florida Department of Environmental Regulation

HAZTECH discussed the permitting process with the City of Fort Lauderdale (the City) officials. HAZTECH understood that permits could be issued within two weeks after application and submittal of required information by a licensed contractor. HAZTECH identified the Departments within the City government which would issue the needed permits:

Building and Zoning Department:

Permit	Required Submittals
Building	Site lay out plan showing locations of all equipment and facilities to be installed; tie-down plans for the construction office trailer
Electrical	Electrical plans and specifications
Fencing	Plans showing the relationship of proposed fencing to buildings, property lines, and city streets

Engineering Department:

Permit	Required Submittals
Traffic Modification	Plans showing obstructions in the right-of-way and required traffic rerouting.
Right-of-Way Construction	Plans showing right-of-way lines, proposed underground pipe routing, location of existing utilities (in particular, existing potable water lines), location of wells and associated fixtures, profiles of proposed piping and existing utilities, details of well fixtures, and details and specifications of piping, paving, drainage, and trenching

The permitting nightmare began in January, 1990, when HAZTECH applied to the South Florida Water Management District (the District) for water well construction and water use permits. The EPA provided the district with pertinent data from the Feasibility Study and the Remedial Design along with a description of the relationships between the EPA, Ebasco and HAZTECH. The EPA also requested that permitting fees be waived. Based on the District's projected review time, we expected the construction permit within two weeks and the water use permit within 45 days.

When contacted about the injection well permits, FDER informed HAZTECH that no permits were required because the wells were part of a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) clean-up and the site groundwater clean-up criteria were within state primary and secondary drinking water standards.

As it turned out, only two permits actually contributed to the difficulties which are the topic of this paper: the City right-of-way construction permit and the District water use permit. We obtained the other permits without adverse impact to cost or schedule.

To obtain the right-of-way construction permit, HAZTECH met with City Engineering Department officials in mid-February 1990 and submitted engineering drawings. After the City engineers reviewed the drawings, they noted that the installation of the above-ground structures, the vaults, might require closure to traffic of all or a part of the public alleyway. Therefore, before they could

issue a permit, the Property and Right-of-Way Committee (the Committee) would have to review the submittals and recommend issuance of a permit. HAZTECH also learned that the City viewed this project as a private rather than a public construction activity and that the City might consider closing the alleyway to traffic for the project duration as a "permanent" closure. If so, a license agreement with the City allowing use of City property for the year-long duration would have to be in place prior to obtaining the construction permit.

Following the meeting, HAZTECH wrote a letter requesting to be placed on the agenda of the next Committee meeting. In an attempt to expedite the project, the EPA Remedial Project Manager (RPM) wrote a letter to the City noting that the project was a joint EPA and FDER project. This letter also described the contractual relationships between the EPA, Ebasco, and HAZTECH.

On March 7, EPA, HAZTECH, and Ebasco representatives attended the Property and Right-of-Way Committee meeting in Fort Lauderdale. The Committee decided that a complete closure of the alleyway for a year was necessary to ensure the public's safety. The Committee expressed concern about the closure's effect on access to adjacent properties. HAZTECH informed the Committee that they had talked with the adjacent business and property owners and encountered no objections to the closure. After further discussion, the Committee decided to approve the closure of the right-of-way under one condition: the owner of the business facing the portion of the alleyway to be closed (Mr. X) must submit a letter stating that he had no objections. The Committee members suggested that they would require a license agreement to use City property, followed by the engineering permit.

The originally scheduled date for site mobilization was March 1, 1990. This schedule had already been delayed a week when the Committee met on March 7. As it turned out, the cost and schedule impacts were just beginning.

Immediately after the meeting, HAZTECH and Ebasco representatives contacted Mr. X to discuss the required consent letter. Mr. X implied an offer to provide the necessary letter in exchange for construction work on his property. HAZTECH declined his offer, and, as a result, received no letter.

HAZTECH notified the Committee that no consent letter would be forthcoming and learned that, as a result, the Committee would need to consider the situation further. HAZTECH requested a slot on the agenda of the next Committee meeting.

During this time, the EPA and Ebasco considered several options to eliminate the need for closing the entire alleyway for the duration of the project. One option involved relocating the two extraction wells from the alleyway onto private property. This relocation would, however, require permission from the property owner, along with the design engineer's review and possible revision to the groundwater modeling used as the basis of the original design. In addition, HAZTECH would need to redesign the piping, perform additional utility searches and property surveys, as well as revise the engineering drawings.

The second option involved placing the wellhead appurtenances in below-grade vaults with traffic-bearing covers, thus necessitating an alleyway closure of only one month during construction. HAZTECH would have to reconfigure the well piping and components, replace the already fabricated above-grade vaults with traffic-bearing below-grade vaults, and revise the drawings. This change would again require a review by the design engineer.

The third option involved shifting the locations of the wells slightly so that the above-grade vaults would block only half the alleyway. This option would require that the piping be installed two feet deeper than planned in order to maintain required clearance from the existing potable water line and that pertinent design drawings be revised.

The EPA decided to use the last option, since it had the least impact on the original design and on the overall cost of the project. HAZTECH prepared revised engineering drawings for submittal to the Committee.

In late March a Committee member visited the site. He viewed the affected section of alleyway and identified several other access routes to Mr. X's property. He acknowledged that the change allowing one open lane for traffic would be helpful in persuading the Committee to delete the requirement for a license agreement so that we would only have to get the engineering construction permit.

On April 4, HAZTECH and Ebasco representatives attended their second Committee meeting. The Committee member who had visited the site recounted his findings and the Committee deleted its requirement for the consent letter. HAZTECH submitted drawings, identifying the revisions allowing half the alleyway to remain open to traffic. The Assistant City Manager agreed that the standard engineering permit was now all that would be required based on code requirements and the fact that the City Engineer had issued permits for similar partial closures in the past.

Disagreeing with this decision, the City Attorney indicated that the City should still require a license agreement. The Attorney was concerned about possible future legal actions by Mr. X. The Attorney suggested that the license agreement include a clause providing the City full indemnification from any legal actions and made the following points:

(1) The project was in the public interest but the location of the wells was for the convenience of the EPA; and

(2) The City was accommodating the EPA by allowing the placement of the wells on city property.

The Committee finally decided on a permitting approach that would require a license agreement containing a special provision for full indemnification of the City from any legal actions.

The Committee recommended this approach at the City Commission meeting and the City Commission approved. On May 9, when the project was ten weeks behind schedule, HAZTECH and Ebasco received the proposed license agreement from the City. This document was to be fully executed by HAZTECH and Ebasco corporate officers as licensees and the City of Fort Lauderdale as licensor prior to the issuance of the engineering construction permit.

After reviewing the document, HAZTECH and Ebasco were concerned about the clauses covering indemnification and insurance. If they signed the document, these clauses would conflict with existing agreements between Ebasco and the EPA and between Ebasco and HAZTECH.

These clauses, extracted from the proposed document, are as follows:

<u>Indemnification</u>

LICENSEE hereby agrees to protect, defend, indemnify, save and hold the CITY, its officers, employees and agents harmless from and against any and all claims, suits, causes of actions or demands of whatsoever nature, including any and all lawsuits, penalties, damages, settlements, judgments, decrees, costs, charges and other expenses including attorneys' fees, or liabilities of any and every kind, nature and degree, in connection with or arising from any activities associated with the project contemplated by the License granted herein. The indemnity and hold harmless herein shall include by way of illustration, but not by way of

limitation, any and all such claims, suits, causes of action, demands relating to personal injury, death, damage to property (including, but not limited to, diminutions in property value, trespass to property, or denial of access to property resulting from activities resulting from the project contemplated by the License herein), or any actual or alleged violation of any constitutional or property right or interest, applicable statute, ordinance, administrative order, rule, or regulation or judicial order, judgment or decree. LICENSEE further agrees to investigate, handle, respond to, provide defense for, and defend any such claims, demands, etc. at its sole expense and agrees to bear all other costs and expenses related thereto, even if the claim is/are groundless, false or fraudulent.

Insurance

Without limiting any of the other obligations or liabilities of LICENSEE, LICENSEE shall provide, pay for and maintain in full force and effect the insurance coverage as set forth in this section at all times during the performance of the operations or projects contemplated by this Revocable License, as will ensure the CITY the protection contained in the foregoing indemnification provisions undertaken by LICENSEE.

Comprehensive General Liability with minimum limits of One Million ($1,000,000.00) Dollars per occurrence combined single limit for Bodily Injury Liability and Property Damage Liability Coverage must be afforded on a form no more restrictive than the latest edition of the Comprehensive General Liability Policy, without restrictive endorsements as approved by the CITY'S Risk Manager, and must include:

a. Premises and Operations; and

b. Notice of Cancellation and Restriction or both --- the policy(ies) must be endorsed to provide the CITY with thirty (30) days' notice of cancellation and/or Restriction.

LICENSEE shall provide CITY with a certified copy of all insurance policies required by this article showing that CITY has been named as insured under such policies or, in the alternative, a certificate evidencing that the required additional endorsement has been obtained under such policies at the time of execution of this Revocable License by LICENSEE.

HAZTECH agreed to sign the license agreement upon assurance from Ebasco that any unanticipated additional incurred costs would become a reimbursable contract modification. Ebasco was concerned about providing open-ended indemnification to the City, along with obtaining and paying for insurance necessary to assure the City of protection required by the indemnification provisions. Ebasco communicated its concerns to the EPA Attorney, as well as to the RPM. Ebasco agreed to sign the document upon assurance from the EPA of full cost reimbursement for expenditures incurred on its behalf. The EPA directed Ebasco to negotiate the indemnification and insurance requirements with the City so that Ebasco could sign the document.

Ebasco legal staff spoke with the City Attorney several times but the City would not modify its requirements. The City's main argument in refusing to modify the indemnification clause was that this case involved a year-long partial closure of public right-of-way, land owners had easement rights to these rights-of-way, and one land owner objected to the closure. Ebasco notified the EPA that negotiations had failed and we had reached an impasse.

The permitting situation had become more, not less, complicated. Site mobilization had been delayed four months. In late June, Ebasco met with the EPA to discuss possible engineering solutions. We had learned that restricting the use of the right of way for more than thirty days required not only a construction permit, but also a license agreement with the City. Therefore, we considered using below-grade instead of above-grade vaults. We hoped that this design change would solve the on-going problems in obtaining a construction permit by eliminating the need for the license agreement. The rationale was that the "below-grade vault" option would eliminate the need for closing the alleyway, except briefly during actual construction.

We thought we had solved the problem. HAZTECH revised the drawings and, after the necessary reviews, submitted them to the City. To our dismay, the City responded in mid-July that it still required a license agreement, although one somewhat different from the original. In the new version, the insurance clause remained unchanged and this sentence had been eliminated from the indemnification clause:

> "The indemnity and hold harmless herein shall include by way of illustration, but not by way of limitation, any and all such claims, suits, causes of action, demands relating to personal injury, death, damage to property (including, but not limited to, diminutions in property value, trespass to property, or denial of access to property resulting from activities resulting from the project contemplated by the License herein), or any actual or alleged violation of any constitutional or property right or interest, applicable statute, ordinance, administrative order, rule, or regulation or judicial order, judgment or decree."

Thus, the revised document was not substantially different from the original one.

When HAZTECH realized that the design change had not solved the problem as anticipated, they considered just starting over. They proposed to bypass the Committee by submitting the newly revised drawings to the City Engineering Department. This proposal seemed logical because the Engineering Department had the authority to issue permits for short-term (less than thirty day) partial right-of-way closures. When approached with the idea, one City official strongly advised against this strategy. He suggested that the City would not alter its requirement for the execution of the license agreement because previous submittals and City requirements were now on record. HAZTECH dropped the idea. The project was four and half months behind schedule and EPA still did not have a construction permit.

By mid-July, the EPA had received all permits except the elusive right-of-way construction permit and the extraction well water use permit from the South Florida Water Management District. EPA's need for the water use permit depended on obtaining the construction permit.

HAZTECH had applied for the water use permit along with all the others in January. In February, the District expressed concern about the elapsed time between the completion of the design and the commencement of the remedial action. They requested additional data because of several new conditions:

(1) The City had applied for increased pumpage from one of its well fields in the vicinity of the site;

(2) Remedial clean-up activities were on-going at the nearby Prospect Well Field; and

(3) Two sites within the immediate vicinity of the Hollingsworth site were undergoing contamination assessment work.

EPA responded to the District's request for additional data by supplying a 1989 groundwater modeling report. In March, Ebasco provided the analytical data from recent groundwater sampling along with current groundwater level data. The EPA then had the groundwater model for the site updated using this new information and data supplied by the District. In late May, the EPA submitted the modelling results which indicated current groundwater flow conditions at the site to the District. This information satisfied the District and it issued the water use permit in mid-August. Although not as frustrating as the construction permit, obtaining this permit took six and a half months instead of the 45 days planned.

By this time, Ebasco senior management and legal staff had completed their review of the revised license agreement. The legal staff advised against signing it. However, senior management wanted to sign it in the interest of maintaining good relations with the client. Ebasco and HAZTECH ultimately decided to sign the license agreement.

In the meantime, the EPA attorney sent a letter to the City attorney. As a result, the City finally proposed satisfactory indemnification and insurance language. The indemnification clause was the same as the previous one except that the following sentence was added:

> "Notwithstanding the foregoing, LICENSEE shall not be liable to so protect, defend, save and hold harmless the Indemnitees to the extent that any such claims, suits, causes of action or demands result from the negligence or fault of any of the Indemnitees."

The City modified the insurance clause to a requirement for maintaining comprehensive general liability insurance. The City deleted the requirement for insurance that would assure the protection required by the indemnification provisions and that named the City as an additional insured.

Ebasco and HAZTECH signed the license agreement in September, the City signed it in October and within a week, HAZTECH obtained the construction permit and Ebasco and HAZTECH had mobilized on-site and were drilling wells.

Mobilization occurred on October 16, 1990, after a delay of seven and a half months. The costs associated with this permitting delay are sobering.

CONCLUSION

The EPA chose to obtain permits for the Hollingsworth Site Remedial Action because of the location of the site and because of the environmental sensitivity and complexity of the aquifer that is the object of the clean-up. In addition to the physical aspects of the site, permitting was warranted by EPA's desire to maintain good working relations with the City of Fort Lauderdale, the FDER, and the South Florida Water Management District because future Superfund actions in the area are anticipated.

What did we learn from this experience? By obtaining permits, EPA helped to alleviate potential future problems and embarrassments due to mishaps involving local community resources. Yet, reflecting on the chronology of events in pursuing these permits, we have the following recommendations:

(1) Consider the specific situation. Because of the dynamic nature of groundwater, when groundwater remediation is included as part of a remedial action, there is a strong potential for permitting delays. This potential increases if the site is located in an environmentally sensitive area and increases even more if the remedial design is not immediately followed by its implementation.

Construction activities within cities are particularly susceptible to permitting problems. Cities sometime hinder activities that are to their citizens' benefit in the process of protecting their infrastructures. We should identify all construction to be carried out on city-owned property and consider the associated permitting implications. Ideally, the design specifies all installations in relation to right-of-way lines and minimizes construction on city-owned property.

(2) Consider other options. In our case, we may have been able to streamline the process, or avoid the permits altogether, and still accomplish our goals. We could have, for example, obtained FDER concurrence on the Superfund permit exemption and then approached the City officials about this exemption.

(3) Begin the planning process early. EPA should not only identify the required permits as early as possible, but should also contact issuing agencies for detailed information concerning required submittals and expected review times. If the design contains sufficiently detailed information, the EPA contractor responsible for obtaining permits can initiate pursuit of them either before or concurrently with subcontractor procurement. Then, even if the permitting agencies require additional and updated information or if design changes are necessary, EPA can minimize or avoid construction delays.

(4) Where possible, determine actual and potential requirements before initiating the permitting process. EPA and its contractors should contact local government and agency officials to discuss the permits on an informal basis. EPA should provide as much detail and get as much information as possible, before making formal submittals. We discovered that once we formally submitted permit applications, we were caught in a web of procedures and requirements that made it difficult to make changes or start over.

(5) Involve appropriate individuals at the first signs of difficulty. One of the pitfalls we experienced was in our treatment of each stumbling block. We approached each impediment as a single problem which when solved would allow us to proceed. In this case, we could have involved the EPA project officer, contracting officer, and attorney as well as the contractor legal staff at an earlier point. These individuals would then have had an opportunity to offer helpful suggestions that may have eliminated or reduced the time and effort we ultimately expended.

(6) Maintain consistent EPA involvement with its contractors as well as with the local governments and agencies. EPA should write a letter to each permitting agency identifying the project as a U.S. EPA Superfund cleanup, describing briefly the project and its expected benefits, identifying the relationships between the EPA, its contractor and subcontractor, naming all the participants, and specifying the type of permit needed. Unfortunately, this procedure will assist, but does not guarantee trouble-free permitting.

Eliminating delays and budget over-runs is an important part of construction management. Permitting is one aspect of every project that can potentially lead to delays and budget overruns. This paper describes a nightmarish situation often repeated in government contracting. There are no simple solutions or short cuts to the permitting process. When complicated by insurance and indemnification issues, the process can take some unexpected twists. An attitude of awareness and forward planning is one of the best tools we have.

DISCLAIMER

The preparation of this document has been funded in part by the United States Environmental Protection Agency. It has been subjected to Agency and Ebasco review and approved for publication. It represents the authors' personal points of view. Any questions or comments regarding the content of this paper should be directed to the authors.

STATE OVERSIGHT AT TWO URANIUM MILL SUPERFUND SITES IN COLORADO

(Author(s) and Address(es) at end of paper)

INTRODUCTION

The State of Colorado has acted as lead agency for oversight at two uranium mill tailings sites, which are also Superfund sites. The two sites are the Uravan Project located in southwestern Colorado near the Colorado-Utah border and the Cotter/Lincoln Park Project located near Canon City, Colorado, approximately 96 miles south of Denver.

When oversight of the projects began, it became apparent that the State needed to develop organized and comprehensive oversight management programs in order to document progress and determine conformance with the approved Remedial Action Plans (RAPs). The oversight management programs provide a detailed road map for inspections and documentation of the actions taken. The oversight programs will ultimately be used to document activities for delisting of these sites from the National Priorities List.

The State of Colorado's strategy on these two sites has been to assign On-Site Coordinators (OSCs) who spend significant time at each site. By spending much of their time on site, the OSCs are aware of current progress, are better able to understand the site conditions and are available to help analyze and solve problems that develop in the field.

No matter how comprehensive the preliminary investigations and studies are, unanticipated conditions are encountered once implementation of a remedial action plan begins. Examples are given of field changes that were made based upon unanticipated conditions such as geohydrology and constructability. The OSCs are empowered to authorize changes in the field in order to accomplish the objectives of the RAPs. This has enabled both projects to proceed in a timely manner but has also required that the OSCs fully understand the purpose and intent of each project component. The time spent at the site observing the construction activities has been beneficial both to the State and to the companies involved.

BACKGROUND

The State of Colorado filed suit in Federal Court against several corporations in December 1983, pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) at seven sites throughout Colorado. During litigation, a Memorandum of Agreement was signed between the U.S. Environmental Protection Agency (EPA) and the State of Colorado (the State). This agreement defined the roles and responsibilities of each agency and made the State lead agency for cleanup oversight at these Superfund

sites. The Uravan and Cotter/Lincoln Park sites had previously been placed on the National Priorities List (NPL) by EPA. The Uravan and Lincoln Park sites were the first two Colorado lawsuits which were settled. The Uravan Consent Decree and the Remedial Action Plan were filed with the court in October 1986 and implementation of the reclamation plan was started in the fall of 1986. The Cotter/Lincoln Park lawsuit was resolved in April 1988 and construction activities began in June 1988.

After settlement of the lawsuits, the State had the responsibility for overseeing the cleanup of contamination at the two uranium mills. Remedial actions are anticipated to take approximately 20 years at each site. The Consent Decrees required that the companies (Umetco Minerals Corporation at Uravan and Cotter Corporation at Cotter/Lincoln Park) perform the remedial activities at their own expense. On-Site Coordinators (OSCs), who have the same authority as that vested in a Federal "On-Scene Coordinator," were hired by the State to oversee implementation of the remedial activities. Although the State has the responsibility for accepting completion of the numerous remedial activities at each site, EPA will make the final decision on delisting each site from the NPL. Therefore, the State On-Site Coordinators work closely with EPA.

The role of the State's two On-Site Coordinators is to ensure proper Quality Assurance/Quality Control and to work with the responsible party to meet the objectives of the respective Remedial Action Plans. To accomplish this, the State has hired consultants to assist. One consultant, W.R. Junge and Associates, developed an Oversight Management Program (OMP) for each site. The Oversight Management Programs were tailored for use by each OSC because each site is different and each Remedial Action Plan is distinct. However, the same basic principles were used in developing each program.

The goal of the OMP is to document, in an organized manner, that all remedial activities at the site have been conducted properly and that these actions meet the applicable, relevant, and appropriate standards. To accomplish this goal, a specific inspection strategy and a detailed inspection system were developed for remedial activities to assure adequate tracking, monitoring, evaluation and documentation of the construction and environmental monitoring activities. In an era of limited resources, it is imperative that an effective, streamlined and manageable system be designed and implemented. For this reason, a computer-based data management system was used in developing the Oversight Management Program. Preparation of these programs required the OSCs to fully understand the scope

of each project. The basic concepts in developing these programs can be used to develop similar programs for other sites that are cleaned up under the Comprehensive Environmental, Response, Compensation and Liability Act (CERCLA); Resource Conservation and Recovery Act (RCRA); and the Uranium Mill Tailings Radiation Control Act (UMTRCA).

Implementation of the RAPs with the onset of field activities uncovered the existence of unanticipated conditions at each site. This situation occurs for each major project undertaken, no matter how extensive the previous investigations. Because the On-Site Coordinators are actually on site, they can quickly be made aware of problems and help to resolve them in an expedient and cost-effective manner. Several examples of field modifications based upon actual field experience are discussed in this paper.

DISCUSSION

Uravan Uranium Mill Site

The Uravan project is located in southwestern Colorado near the Colorado-Utah border (Figure 1). The site consists of approximately 10 million cubic yards of uranium tailings located in two piles on a structural bench approximately 100 feet above the San Miguel River. Six ponds, referred to as the Club Ranch Ponds, containing evaporated residues from liquid mill waste, called raffinate, are also present in the river valley. Deposits of remnant tailings and a pile of raffinate crystals removed from the Club Ranch Ponds are also located in the river valley. Contaminated soils and other materials are also present in the mill area. The company-owned town of Uravan once existed in the river valley but was removed in 1987 as a part of the Remedial Action Plan.

Activity at the site commenced in 1913 with the construction of the first radium mill. Operation of a vanadium mill at Uravan started in 1936. By 1944, Union Carbide, under contract to the U.S. Army Corps of Engineers, was processing uranium at the site for use in the Manhattan Project. The possibilities of beneficial uses of atomic energy and radioactive materials led to the formation of the United States Atomic Energy Commission and the birth of the uranium industry in Colorado. Construction of the large tailings piles at the site started in the 1940's and continued until 1984 when Union Carbide suspended operations at the site. The construction of the Club Ranch Ponds for containment and evaporation of mill liquors commenced in the middle to late 1950's. These ponds continued to be used until 1988.

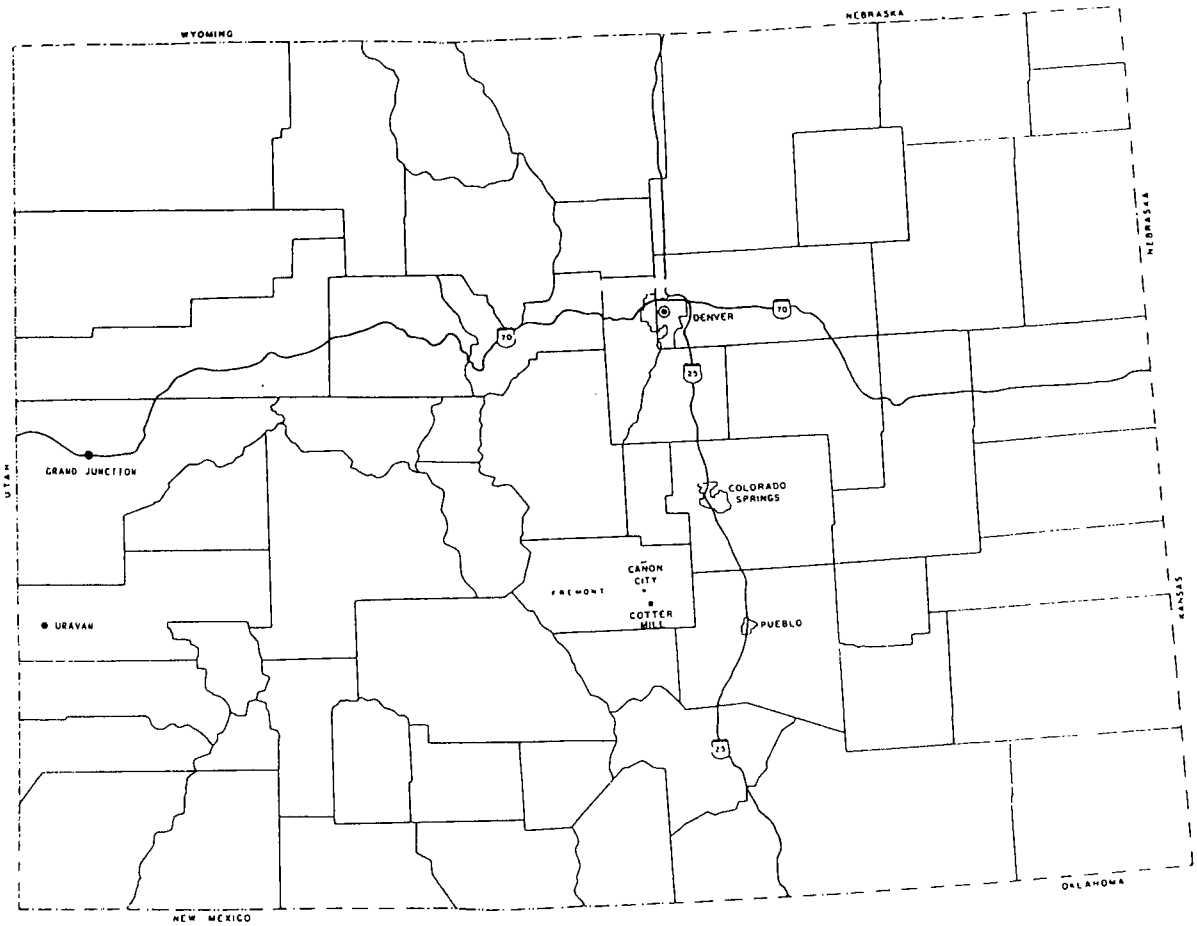

Figure 1. Map showing the location of the Uravan and Cotter mill sites.

The remedial actions at the Uravan site include consolidation of all tailings and contaminated soils into the two existing tailings piles. The tailings piles will be capped with a multi-layer earthen and rock cover designed to reduce infiltration and erosion. The raffinate crystals are to be placed in a below-grade, clay-lined repository located adjacent to the tailings piles. Approximately 550,000 cubic yards (cy) of the estimated 800,000 cy of crystals have been moved. Approximately 450,000 cy of the estimated 600,000 cy of remnant tailings and contaminated soils have been moved and consolidated.

Control of contaminated liquids at the Uravan site includes interception of hillside seepage below the tailings piles and withdrawal of contaminated ground water from underneath the valley area. Treatment for both systems involves evaporation of the contaminated liquids in double-lined ponds equipped with leak detection systems.

Implementation of the Remedial Action Plan at Uravan is on schedule and is ahead of schedule for some elements. This is due to an abundance of dry weather and cooperation between the company and the State of Colorado in implementing the remedy.

Uravan Oversight Management Program

One of the first tasks undertaken by the company, once the Consent Decree was ratified by the Court, was the preparation and submission to the State of Plans and Specifications for the construction of the remedial actions at the site. During the review of the Plans and Specifications for the Uravan Project, it became evident that an organized, comprehensive state oversight program would be needed in order to track the progress of the project and to keep the On-Site Coordinator organized during the inspection of numerous project elements. The Uravan Project is broken down into thirty sub-projects and literally hundreds of project elements in the Plans and Specifications. A step-wise, building-block approach is needed to inspect such a project. The Uravan RAP calls for a Construction Report to be submitted at the completion of each sub-project. Each sub-project is in turn broken down into tasks and each task is composed of individual project elements. At the completion of each task, a Compliance Report is submitted to the State for review and approval. These reports contain a description of the work performed, the results of the quality control tests, such as liner seam tests or soils compaction tests and any field changes made, including

an explanation of the conditions leading to the changes. The Compliance Reports are then compiled for each task and submitted together with As-Built Drawings as the Final Construction Report for each sub-project.

It is particularly important to catalogue and inspect the various project elements because, once an element is constructed, it is often covered up by future work. In order for the State to certify that the entire project has been properly completed, each project element must be inspected to determine conformance with the Remedial Action Plan and the approved Plans and Specifications.

The establishment of an Oversight Management Program for the Uravan Site was undertaken by the State in late 1987 and was completed in February of 1988. The program consists of a series of data base computer files that track the status of documents, construction dates, project elements and inspection dates.

Figure 2 shows the format of the document log file. This file tracks the submittal dates for the most current revision of approved plans, as well as the Final Construction Report for each sub-project and the performance evaluation report. The revision number for each document is contained in the file but not shown in this figure.

A portion of the Construction Tracking Progress Report is shown in Figure 3. This data base contains the actual and required start dates and completion dates for each sub-project as specified by the Remedial Action Plan.

A third file, the Construction Database, contains a break out of each sub-project into tasks and elements. The Compliance Report number for each task and element is also specified. This file tracks dates of inspections for each element and the approval date for each task. A text file within the construction database contains a description of how each element is to be inspected. Inspection results and other field observations are also recorded in this file. This allows the production of an inspection report from one file. Field changes are handled in another text file.

Several types of reports or data summaries can be generated from the Construction Database, including Inspection Reports, Project Summary Reports and Inspection Tracking Reports. These summaries can be used to update interested parties regarding the progress of the project.

The Inspection Tracking Report (Figure 4) shows the inspection status of each element for each task. This file allows Department management and the OSC to gauge the progress of each task as well as the progress of the OSC in inspecting each project element or task. A text file also exists within the data base for each project element, task and sub-project. The file can be updated as additional elements are inspected.

The Project Summary Report shown in Figure 5, taken from the Construction Database, is a compilation of sub-projects and major tasks with the Compliance Report number for each task. This report summarizes the status of compliance reports submitted by the company for each portion of the entire project.

When a Compliance Report is submitted by the company, the Construction Database text file for each construction element is reviewed to determine if any unresolved problems exist. The text files for each element of the Compliance Report is a record of the State's inspection and approval of the construction task.

The approval of a Final Construction Report is handled in the same way and is composed from the inspection report text file for each construction task.

The State Oversight Management Program at Uravan has been used primarily as an inspection guide and inspection record. Efficiency of OSC field review activities is improved by the use of the program. This allows the OSC to preview the important inspection activities for each construction element and to act in a quality assurance role during inspections.

The Oversight Management Program is an on-going record of activities at the site. Ultimately, the program will be used to verify compliance with the Remedial Action Plan and to allow delisting of the site.

Armed with the Oversight Management Program and a thorough knowledge of the goals of the Remedial Action Plan, the OSC is prepared to deal with the challenges of implementation.

Uravan Field Oversight

In several instances, unanticipated field conditions were encountered during construction of the various phases of the project. The presence of the State's On-Site Coordinator at the site during these instances provided useful and important insight into the problem. Solutions were discussed in the field with engineers and construction personnel, which allowed

UMETCO-URAVAN

Document Tracking Log

CONSTRUCTION AREA	DOCUMENT NUMBER	DATE SUBMITTED	DATE APPROVED
400 ATKINSON CREEK AREA			
400.0 Final Plans	S-400-1	06/09/87	02/09/88
400.1 Quality Plan	QP-400-1	06/09/87	02/09/88
400.2 Final Constr Rept.			
400.4 Design Changes			
400.9 Performance Eval.	PE-400-1		
401 CLUB RANCH PONDS			
401.0 Final Plans	S-401-1	04/03/87	08/11/87
401.1 Quality Plan	QP-401-1	04/03/87	08/11/87
401.2.1 Constr Rept.			
401.2 Final Constr Rept.			
401.4 Design Changes			
401.13 Performance Eval.	PE-401-1		
402 RIVER PONDS AREA			
402.0 Final Plans	S-402-1	06/09/87	02/09/88
402.1 Quality Plan	QP-402-1	06/09/87	02/09/88
402.2 Final Constr Rept.			
402.4 Design Changes			
402.7 Performance Eval.	PE-402-1		
404 TAILINGS PONDS			
404.0 Final Plans	S-404-1	06/12/87	02/09/88
404.1 Quality Plan	QP-404-1	06/12/87	02/09/88
404.2 Final Constr Rept.			
404.4 Design Changes			
404.11 Performance Eval.	PE-404-1		
406 CLUB MESA AREA			
406.0 Final Plans	S-406-1	06/09/87	02/09/88
406.1 Quality Plan	QP-406-1	06/09/87	02/09/88
406.2 Final Constr Rept.			
406.4 Design Changes			
406.9 Performance Eval.	PE-406-1		
413 MILL AREA			
413.0 Final Plans	S-413-1	06/09/87	02/09/88
413.1 Quality Plan	QP-413-1	06/09/87	02/09/88
413.2 Final Constr Rept.			
413.4 Design Changes			
413.12 Performance Eval.	PE-413-1		

Figure 2
A portion of the Document Log Tracking File
for the Uravan Project

UMETCO-URAVAN
Construction Log
Progress Report

	CONSTRUCTION ACTIVITY	INITIAL DATE Required	INITIAL DATE Actual	COMPLETION DATE Required	COMPLETION DATE Actual
400	ATKINSON CREEK DISPOSAL AREA	06/30/92		12/31/93	
	Remove Contaminated Materials	None		12/31/92	
401	EXISTING CLUB RANCH PONDS				
	Cease Discharge to CRP'S	None		06/01/88	05/31/88
	Remove Club Ranch Pond Liquids	None	10/06/88	12/31/88	12/23/88
	Remove Contaminated Materials	09/30/89	09/21/89	12/31/88	
	Lining of the Club Ranch Ponds	None		12/31/91	
	Remove New Pond Liners	None		None	
	Final Reclamation	None		PER RAP	
402	RIVER POND AREA				
	Cease Discharge to River Ponds	None	02/17/88	04/13/87	02/17/87
	Remove Liquids from Ponds	12/31/87	12/15/87	Annual	04/26/89
	Remove Contaminated Materials	09/30/89	09/29/89	12/31/88	04/26/89
	Final Reclamation	None	08/13/90	12/31/91	09/07/90
404	TAILINGS PILES				
	Dewater Tailings Piles	09/30/88	09/22/88	None	
	Cease Storage of Liquids TP#2	None		12/31/89	04/05/89
	Side Slope Cover	04/30/88	09/12/88	12/31/89	09/13/89
	Top Cover-Clay and Random Fill	None		12/31/96	
	Top Cover-Riprap	None		None	
	Diversion Channels	None		12/31/96	
406	CLUB MESA AREA				
	Remove Contaminated Materials	06/30/93	09/06/89	12/31/94	
	Install Runoff Controls	None	07/25/90	06/30/93	
	Remove Storage Pond Liquids	None		Annual	
	Final Reclamation	None		12/31/95	
413	MILLS AREA				
	Removal of Heap Leach Site	None	Fall 86	12/31/88	11/20/88
	Removal of Barrels	None	12/05/87	12/31/87	02/16/88
	Removal of Boneyard Material	None	02/18/87	12/31/88	12/07/88
	Final Reclamation	None		None	

Figure 3
A portion of the Construction Log Tracking file
showing start dates and completion dates for each sub-project.

UMETCO-URAVAN SITE
STATE INSPECTION REPORT
1990 INSPECTION UPDATE

CONSTRUCTION TASK	INSPECTION DATE	APPROVAL DATE	STATUS
404 TAILINGS PILES			Pending
404.5 DEWATERING LIQUIDS ON TAILINGS PILES	04/18/89	04/18/89	Pass
404.5.1 Inspect Surface Water Collection System	09/21/88	04/18/89	Pass
404.5.2 Verify Construction of Ditches and Sumps	09/21/88	04/18/89	Pass
404.5.3 Confirm Minimum Pool Size	09/21/88	04/18/89	Pass
404.6 PLACEMENT OF CONTAMINATED MATERIAL			
404.6.2 Verify Size, Shape, Nesting of Scrap	08/15/88		Pending
404.6.3 Observe Placement of Contamination Mat'l	12/12/89		Pending
404.6.4 Check Contaminated Material Soils Tests	09/28/89		Pending
404.7 RIPRAP COVER FOR ROCK BUTTRESS		11/20/89	Pass
404.7.1 Confirm Riprap Specifications	09/28/89	11/20/89	Pass
404.7.2 Observe Riprap Placement	06/20/89	11/20/89	Pass
404.7.3 Observe Riprap Compaction	03/14/89	11/20/89	Pass
404.7.4 Verify Riprap Thickness	09/28/89	11/20/89	Pass
404.8 RECLAMATION COVER FOR EXISTING 3:1 SLOPES		11/20/89	Pass
404.8.1 Confirm Thickness&Compaction/Exist. Fill	06/20/89	11/20/89	Pass
404.8.2 Confirm Clayey Soil Material Properties	09/22/88	11/20/89	Pass
404.8.3 Observe Clayey Soil Placement	08/16/89	11/20/89	Pass
404.8.5 Check Clayey Soil Tests	05/16/89	11/20/89	Pass
404.8.6 Verify Clayey Soil Thickness	09/29/89	11/20/89	Pass
404.8.7 Confirm Random Fill Material Properties	10/20/88	11/20/89	Pass
404.8.8 Observe Random Fill Placement	07/05/89	11/20/89	Pass
404.8.9 Observe Random Fill Compaction	07/05/89	11/20/89	Pass
404.8.10 Check Random Fill Soil Tests	06/13/89	11/20/89	Pass
404.8.11 Verify Random Fill Thickness	09/29/89	11/20/89	Pass
404.8.12 Confirm Riprap Specifications	09/28/89	11/20/89	Pass
404.8.13 Observe Riprap Placement	09/28/89	11/20/89	Pass
404.8.14 Observe Riprap Compaction	03/28/89	11/20/89	Pass
404.8.15 Verify Riprap Thickness	09/28/89	11/20/89	Pass
404.9 RECLAMATION COVER FOR 5:1 SLOPES AND TOP			1995
404.9.1 Confirm Placement of Interim Cover			
404.9.2 Confirm Compaction of Interim Cover	07/16/90		n/a

Figure 4
A Portion of the Inspection Tracking Report.
This information is stored in the Construction Database.

UMETCO-URAVAN SITE
PROJECT SUMMARY
CONSTRUCTION SEGMENTS

CONSTRUCTION SEGMENT	COMPLIANCE REPORT	APPROVAL DATE	STATUS
400.0 ATKINSON CREEK CRYSTAL AREA			1992
400.5 SURFACE RUNOFF CONTROL FACILITIES	CR-400-1		1992
400.6 CLEANUP OF CONTAMINATED MATERIALS	CR-400-2		1992
400.7 INSTALLATION OF SYNTHETIC LINERS	CR-400-3		1992
400.8 FINAL RECLAMATION	CR-400-4		1993
401. CLUB RANCH PONDS AREA			Pending
401.5 SURFACE RUNOFF CONTROL FACILITIES	CR-401-1		Pending
401.6 CLEANUP OF CONTAMINATED MATERIALS	CR-401-2	04/20/89	Pass
401.7 INITIAL REMOVAL/RAFFINATE CRYSTALS & SOIL	CR-401-3		Pending
401.8 PREPARATION FOR LINING EXISTING CRP (1-6)	CR-401-4		Pending
401.9 CONSTRUCTION OF THE LEAK DETECTION SYSTEM	CR-401-5		Pending
401.10 INSTALLATION OF SYNTHETIC LINERS	CR-401-6		Pending
401.11 FINAL CLEANUP	CR-401-7		2003
401.12 FINAL RECLAMATION	CR-401-8		2003
402. RIVER PONDS AREA			Pending
402.5 SURFACE RUNOFF CONTROL FACILITIES	CR-402-1	04/20/89	Pass
402.6 CLEANUP OF CONTAMINATION MATERIALS	CR-402-2	11/26/90	Pass
402.7 FINAL RECLAMATION	CR-402-3	11/26/90	Pass
404. TAILINGS PILES			Pending
404.5 DEWATERING LIQUIDS ON TAILINGS PILES	CR-404-1	04/18/89	Pass
404.6 PLACEMENT OF CONTAMINATED MATERIAL	CR-404-2		Pending
404.7 RIPRAP COVER FOR ROCK BUTTRESS	CR-404-3	11/20/89	Pass
404.8 RECLAMATION COVER FOR EXISTING 3:1 SLOPES	CR-404-4	11/20/89	Pass
404.9 RECLAMATION COVER FOR 5:1 SLOPES AND TOP	CR-404-5	11/20/89	1995
404.10 SURFACE RUNOFF CONTROL FACILITIES	CR-404-6		Pending
404.11 MONITORING DEVICES	CR-404-7		Pending

Figure 5
A portion of the Project Summary Report taken
from the Construction Database File

for development of workable solutions and achievement of constructable remedies that attained the goals of the Remedial Action Plan.

As an example, one of the first projects undertaken was the construction of two 15-acre evaporation ponds in the valley. These ponds were placed adjacent to the six existing unlined raffinate containment ponds. During the course of pond excavation, it was found that seepage from the existing ponds was migrating upvalley into the new pond area. The project engineer, OSC and the construction foreman evaluated the problem in the field. It was decided to excavate a trench to bedrock in order to intercept the seepage. In addition, the design of the one affected pond was modified by adding a seepage interception drain under one corner at a level below the leak detection system. In a matter of three hours, a solution to the problem had been agreed upon and construction initiated. The trench sump was monitored and showed a steady decrease in flow. Within sixty (60) days all flow from the trench had stopped.

The design of the leak detection system for the evaporation ponds is another area where field modifications were made. The original design specified in the RAP called for three parallel drain lines underneath each pond. These lines converged to a single sump.

As construction progressed, it became evident that the leak detection system did not cover some critical areas of the ponds and was short in comparison to the length of seams in the synthetic liner. The system was redesigned to a dendritic pattern in order to cover more areas and was also made longer. The final design decisions on location and extent of the system were made in the field.

In another instance, problems arose with the placement of the raffinate crystals in the crystal repository. The raffinate crystals have a hygroscopic nature and are largely composed of water (moisture content-70%). Excavation caused breakdown of the solid crystals and appeared to increase the free water content due to the further breakdown of the crystals. Placement of the crystals also appeared to increase the free water content. Unlike soil, the free moisture content of the crystals increased as the material was worked. This phenomenon was observed in the field early in the placement process as pumping was obvious. The project engineer, OSC and construction manager met and discussed the problem. Through trial and error and field observation, a series of procedures were developed to handle crystals with varying moisture

contents. The key element was to avoid handling the crystals as much as possible. Lift thicknesses were allowed up to four feet for wetter material. The lifts were placed in segregated cells and allowed to "set up". In 3 to 5 days depending upon the weather conditions, the cells would "set up" much like concrete. Several cells were excavated in order to determine the degree of compaction and consolidation of the lifts. Sand cone and standard Proctor density tests using a single point method were also conducted to confirm compaction.

The development and use of a State Oversight Management Program has benefited the Uravan project by organizing the inspection activities to be conducted in an enforcement role. With the existence of the Oversight Management Program, the emphasis has been on evaluating and solving problems in the field by allowing the State OSC to operate in a quality assurance capacity.

The ability of the OSC to be on-site to observe field conditions encountered and to approve changes in the field has allowed the Uravan cleanup to proceed in a timely manner with minimum delays and at a cost saving to the company. The OSC must have a complete understanding of the intent and content of the RAP in order to make timely and correct decisions. The Oversight Management Program for Uravan is one tool that is useful for this task.

Cotter Uranium Mill Site

Cotter Corporation (Cotter) is a uranium mining and milling company that owns and operates a uranium-vanadium mill near Canon City, Colorado. The Cotter Canon City mill site is located in Fremont County in the south central part of Colorado, approximately 96 miles south of Denver (see Figure 1) and two miles south of Canon City.

The Cotter mill facility, which was constructed in 1958, produces uranium concentrate (yellowcake) and recovers molybdenum and vanadium as a byproduct. The mill is licensed by the Colorado Department of Health, but has not operated since 1987 because of the low cost of uranium from foreign competitors.

The Cotter site includes approximately 1.4 square miles (880 acres) and contains an inactive mill (alkaline leach process), an active mill (acid leach process), a partially reclaimed tailings pond disposal area and an active tailings pond disposal area. During operation of the old mill from 1958 thru 1979, tailings and liquids (raffinate) were disposed on site

into several unlined ponds (Figure 6). During the period from 1978 to 1981, two new clay- and synthetic-lined impoundments were constructed. The raffinate was transferred into the primary impoundment and the solid tailings were transported into the secondary impoundment. The primary impoundment is presently being used for storage of the acid leach mill tailings and water from ground water interception facilities.

The mill site is located within the drainage area of Sand Creek. Sand Creek is an ephemeral stream until it nears the Arkansas River, where it becomes perennial. The Sand Creek channel travels in a northerly direction from the mill, under a flood control dam constructed by the Soil Conservation Service in 1971, into a suburb of Canon City called Lincoln Park and eventually enters the Arkansas River. Lincoln Park is the name the EPA used when the site was placed on the NPL.

The major source of contamination is located in the area where the tailings were originally stored in unlined ponds. The mill-derived constituents found in the uranium tailings were released to ground water on-site and generally followed the Sand Creek drainage into Lincoln Park and into the Arkansas River.

Historically, the Soil Conservation Service (SCS) dam prevented surface water flow from the site into Lincoln Park. However, hydrologic and water quality data indicated that a shallow ground water pathway existed beneath the SCS dam. This pathway allowed ground water to migrate from the site into Lincoln Park. Since this was a major pathway of contamination, the Remedial Action Plan (RAP), agreed to by Cotter and the State, required Cotter to construct a clay hydrologic barrier and water withdrawal system at the upstream side of the SCS dam. Other remedial activities included construction of ground water flushing systems and additional monitoring wells; expansion of the secondary impoundment; further removal of soils; and additional studies of surface water and soils media.

Cotter Field Oversight

At the SCS dam, the RAP required a trench to be excavated to the Vermejo shale formation, which dips 11 degrees in a southerly direction below the dam and towards the mill site. The Vermejo Formation outcrops near the crest of the dam. After the trench was excavated into the shale and verified by the OSC, a 14-foot-thick, compacted layer of clay soil was placed at the downstream end of the trench and the over-excavated area was backfilled with loosely-placed random fill. As part of the water recovery system, a 2-foot-wide

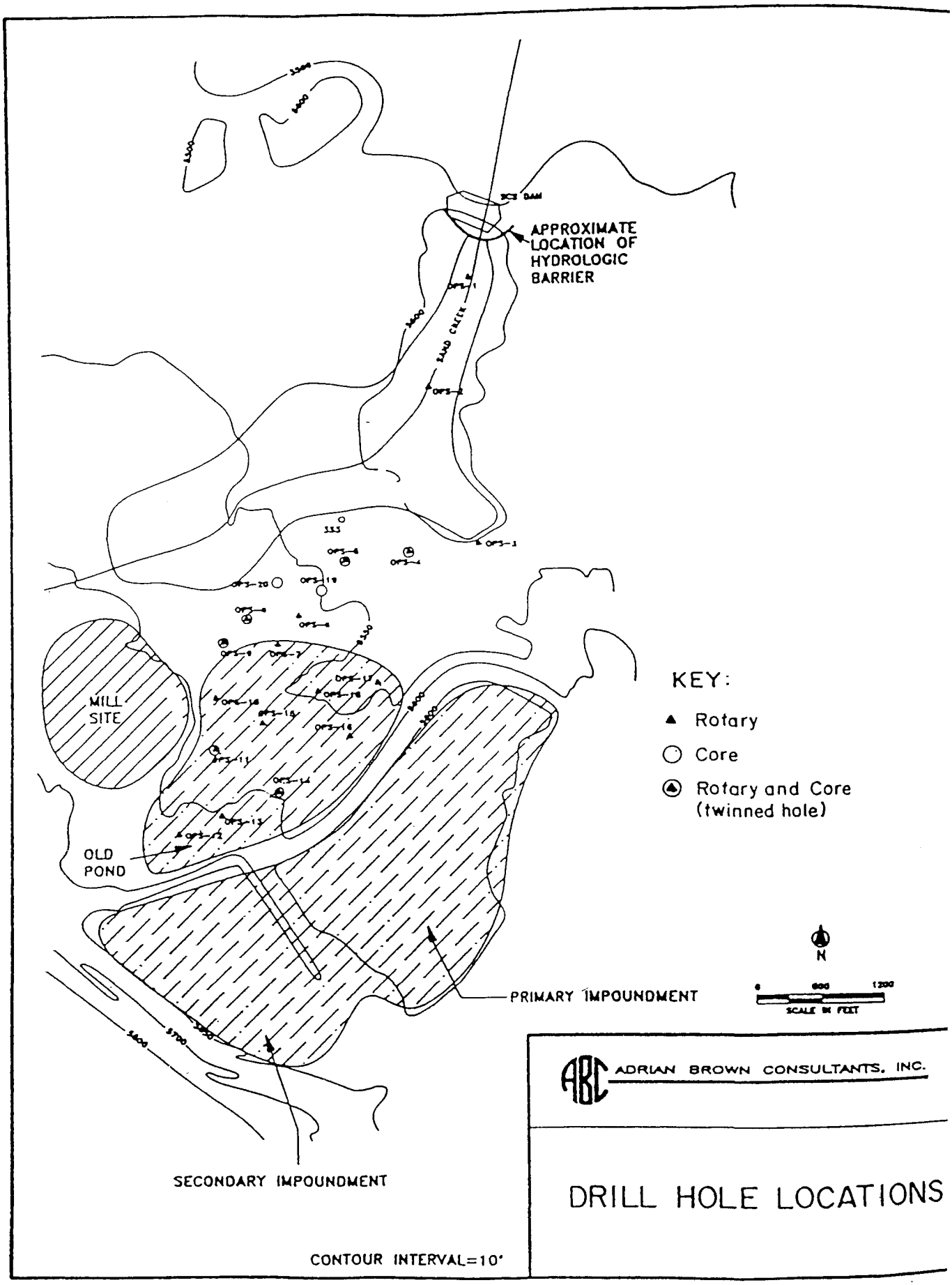

Figure 6 - Cotter Uranium Mill Site Map

drain material (pea gravel) was to be placed against the upstream wall of the trench. This proved to be impractical as the excavated material was primarily alluvium, which constantly sloughed during excavation. This caused over-excavation and created an uneven upstream face. The construction of the 2-foot-thick gravel drain proved to be impossible, as shown on the construction drawing (Figure 7). The contractor proposed constructing a vertical trench in the random fill (Figure 8). First, the random fill would be placed in 2-foot layers; then, a backhoe would excavate the trench. The trench would be back filled with pea gravel and then another 2-foot layer of uncompacted random fill would be placed before excavating the trench through the random fill to the pea gravel. During the excavation of the trench, any random fill that caved in on the gravel was removed by hand. This system worked because it made construction easier, inspection of the trench and fill was easy to do, and it met the intent of the remedial activity. The system has been operable with no problems for 2 1/2 years.

In the fall of 1988, Cotter expanded the secondary impoundment by raising the side slopes around the east portion of the impoundment with compacted clay. A forty mil synthetic liner was then connected to the old liner, which had been placed in operation in 1980. The impoundment was then flooded with highly acidic (pH 2.0) raffinate. During the fall of 1989, a mill worker performing a routine inspection observed a soft area underneath the exposed liner. Cotter management and the On-Site Coordinator were immediately informed. An investigation followed.

Because the pond was only a few feet deep, a clay dike was constructed to isolate the problem area. Liquid within the dike enclosed area was drained and the liner was exposed. The seam between the old and the new liner was intact, but several small holes were observed. These were mostly in the new liner. The liner was removed in the problem area. It was observed that only the upper few inches of the underlying clay liner were impacted by the raffinate. The soft, wet clay was removed, replaced with clean clay and recompacted. The liner was then replaced. There have been no other observed problems with the liner.

Since the State representative was on-site, he was available to be immediately notified of the problem, to observe the investigation, to participate in the resolution of the problem and to assure that the remedial activities were performed properly.

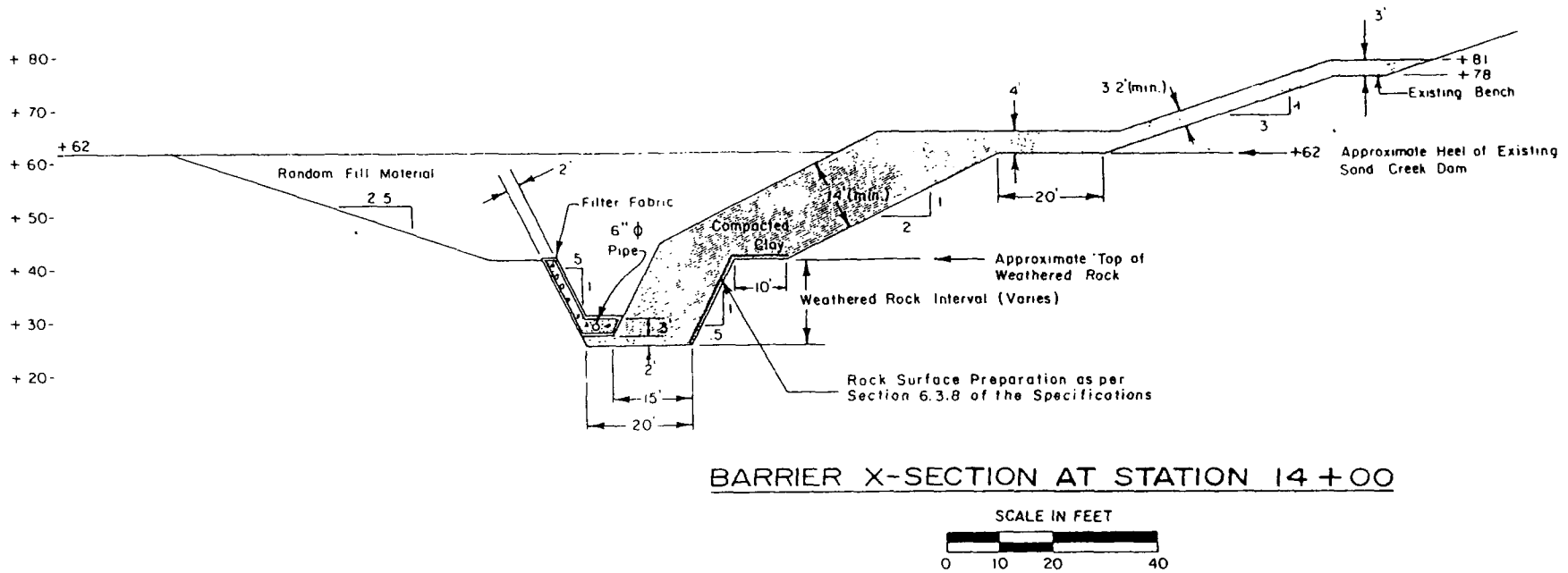

Figure 7 - Engineering Design for Construction of the Clay Hydrologic Barrier and Gravel Drain

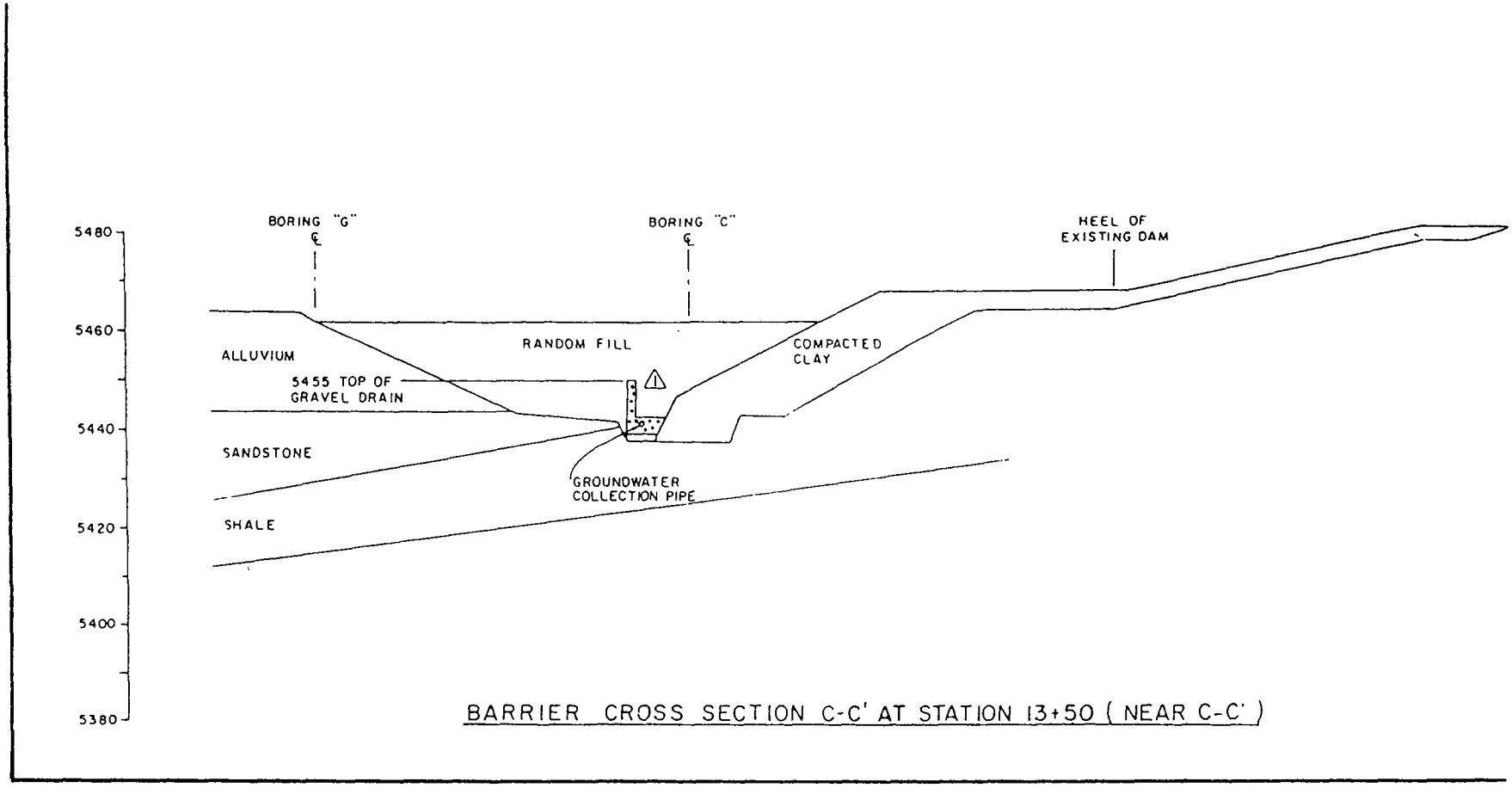

Figure 8 - Construction As-Built Drawing of the Hydrologic Barrier and Gravel Drain

Cotter Oversight Managment Program

Both the Uravan and Cotter Oversight Management Programs were tied directly to requirements set forth in the respective remedial action plans.

However, the Cotter RAP was considerably different than the Uravan Remedial Action Plan. While the Uravan plan was primarily construction-oriented, Cotter's plan required several studies to be completed off-site, besides doing remedial construction activities on-site. Therefore, the Oversight Management Program (OMP) at Cotter had to be set up differently than at Uravan.

The Cotter OMP requirements included following the schedule for remedial activities, preparing plans and reports, and

conducting specific remedial actions. The OMP was divided into two key systems. The systems were termed (1) Status of Remedial Activities and (2) Oversight Activities.

The Status of Remedial Activities system provided a method to track scheduled activities and report requirements set forth in the RAP. This sub-program was used to track scheduled dates required in the RAP, to verify that these dates had been met, to assist in the planning of the State's oversight activities, and to record the State's approval of the documents or activities.

The Oversight Activities system described the specific inspection and review activities, including corrective actions, if necessary, to be conducted by the State's On-Site Coordinator.

The Oversight Activities sub-program was used to verify that remedial activities at the site were conducted in accordance with the RAP requirements; to provide a detailed, retrievable record of State oversight activities; and to confirm that the requirements set forth in the RAP were completed successfully.

Memo fields were provided for each oversight activity so that inspection or review notes could be entered, reviewed, and edited if necessary. Additionally, memo fields were provided for recording non conformance items and corrective actions. All memo fields were keyed to the date of inspection, the subject of the inspection and the inspector. A specific oversight activity may be inspected more than once and, accordingly, entered in the memo fields.

Although the Uravan and Cotter remedial programs are different, the Oversight Management Programs developed for the State have been very beneficial and successful. It has also been adapted for use at other Superfund sites in Colorado, where the State is responsible for oversight management.

CONCLUSION

The Oversight Management Programs were developed as a tool for eventual delisting of State lead Superfund sites from the National Priorities List. As these sites are projected to take over twenty years for remedial action to be completed, it is likely that different personnel will be around than those who started the job. Therefore, the State had to find a way for the OSCs responsible for delisting the sites (possibly in the year 2010) to have all of the information available to them, presented in a succinct but complete manner, without having to go through thousands and thousands of records. It is

anticipated that, the Oversight Management Programs written for the Uravan and Cotter Superfund sites will accomplish this task.

The State of Colorado's experience with oversight has been that:

1. Organization of the project through the use of a simple oversight management program is imperative to assure and to document that the activities are being performed in accordance with the intent of the Remedial Action Plans. Program development has also focused attention on the intent and purposes of the Remedial Action Plan for each site.

2. The ability of the OSCs to be on-site is critical to the understanding of problems that arise. The on-site presence reduces misunderstandings about conditions observed and minimizes projected delays. Project delays have been further minimized by allowing the OSCs to approve many changes in the field.

The State of Colorado's approach to project oversight has provided five important benefits:

1. The site remedial action plan is well defined;

2. Implementation of the remedial action plan is well documented;

3. The site conditions and situation are understood;

4. Additional quality assurance is provided; and

5. Project delays and costs are minimized.

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Mobilizing for Remedial Construction Projects

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INTRODUCTION

The start of a remediation project is an exciting time. Expectations are high for a successful project. The design and studies are now complete and the engineers can start to realize the fruition of their labors. The local populace can see first hand that the problem near to them is now being remediated. The mobilization of the project occurs after the remediation contract has been signed and prior to the remediation starting in the field. However, unless the mobilizing of the project is completed as scheduled and within budget, this excitement may turn to despair.

The mobilization of the field construction forces and materials is a critical time in the project. Plans have to be written and filed, equipment delivered onsite, and personnel trained. This paper will explore the requirements for a successful mobilization and develop a checklist that the project or construction manager can utilize to ensure that this activity will be complete as required and when needed.

Most remediation companies have procedures to be followed or plans to be approved prior to starting onsite. The contract with the client may also have submittals and policies that have to be completed or followed prior to starting onsite. Examples of these submittals are:

- Quality Control/Quality Assurance Procedures and Plan
- Site Health, Safety, and Emergency Response Plan
- Work Plans
- Disposal Studies
- Project Schedule
- Cost Estimate

In addition to the early plans, the mobilization itself entails planning and procurement to ensure that the project is ready to start on time with all necessary materials on hand.

The four major areas of mobilization to be discussed in the following paragraphs are plans and submittals, project controls, procurements and the onsite mobilization.

BACKGROUND

The activities described in this paper are for a remediation project that is ready to start in the field. The record of decision has been issued and the design is complete. The client has awarded the work to a remediation firm and requires specific documentation prior to starting onsite. The scope of the project is for construction only and does not include detailed design or definition of the overall remediation approach.

DISCUSSION

PLANS AND SUBMITTALS

Prior to the start of the remediation, many clients require plans and reports to be written and approved. For example, the U.S. Army Corps of Engineer projects require the submittal and approval of definite plans such as the Quality Assurance/Control Plan, Site Health and Safety Plan, Work Management Plan, and an environmental report. Most remediation companies also require the corporate approval of these plans prior to construction.

The Quality Assurance/Control Plan (QAP) defines the corporate management structure required to ensure a successful project. The Quality Assurance management team assigned to the project will be identified. The person(s) onsite who is responsible for the QA/QC functions will be named. This person will usually report directly into the corporate department and indirectly to the site manager. It is expected that a member of the firm's senior management will be assigned to oversee the project.

The QAP will also identify what site specific tests are to be performed and what work is to be witnessed. These steps will help to verify that the quality of work being installed is as specified. The timing and frequency of the tests will be listed so the site quality assurance person will be available to supervise.

The Site Health, Safety and Emergency Response Plan (SHERP) is probably the most important submittal of the pre-construction period. This report includes both general construction and remedial construction components of the work.

The SHERP consists of five main section. The first section deals with the scope of work for the project. The remediation technique and the contaminants to be removed would be described in this section. Owner furnished materials and services are identified so the contractor will not provide nor perform more work than they contracted. This section should reiterate the contractual scope of work and provide the basis for the work plan.

The second section is the listing of hazards associated with the project. The hazards can include physical, chemical, biological, and weather. Physical hazards can be the structural integrity of the facility for the personnel to travel through. They also can refer to debris or buried objects in the ground.

Chemical hazards refer to the chemicals and contaminants that are found on the site. Pre-construction sampling for the design has usually identified the chemicals. The characteristics of the chemicals and their effects are also listed in the section.

The biological hazards can include both wastes and animals. The presence of biological waste at the site represents problems that need to be identified. Animals at a site can pose a definite threat to the workers. Bites from snakes, dogs, and insects can injure or disable the workers.

The weather conditions are a hazard to the workers who must wear personal protective equipment. Hot sunny weather will limit the time in the suits and can cause heat stroke or other disabilities.

The scope of work and list of hazards are the basis of the next two sections which are risk assessment and level of protection requirements. The risk assessment will break down the scope of work into distinct activities where identifiable risks are present. Some risks, such as wildlife and exposure, can impact the entire project, whereas the chemical contaminants may only affect parts.

The level of protection required for the different stages of the work is based on the risk assessment. Based on engineering, proper work sequences will be established that may minimize or lessen the level of protection. Having a worker in a high level of protection should only occur if engineering modifications or construction sequencing cannot help lessen the level. The air and site monitoring that is required will be described in this section.

The final section of the SHERP deals with the contingency plans for project. These plans are the basis for action if something goes wrong such as an injury occurs, fumes escape, or liquids spill. The escape routes, hospitals and doctors are all listed so the field personnel can react.

Other submittals that may be required are the security, environmental, and disposal plans. Depending on the client, project and corporate requirements, these documents can be lengthy and detailed.

The security plan outlines how to secure the site for the duration of the project in order to minimize disruptions. Fencing and guard services are examples of the approaches.

The environmental plan discusses how the immediate area around the site can be protected from onsite contaminates caused by the remediation. During excavation and site work, dust control is a problem which can be remedied by watering the site. To minimize soil runoff, methods of erosion and sedimentation control are defined. Pre-construction surveys to define background limits for air and water are outlined and the tools listed.

The disposal plan will list the wastes that have to be disposed of offsite. Included in this plan are the methods of transport of the wastes, what wastes are hazardous or non-hazardous, and the required disposal procedure. The disposal facilities that are to be utilized are also to be listed in this plan.

As part of the early submittals, the project team must review what permits are required for the work. Local or state officials may need to be notified. Fire, building or demolition permits usually take weeks to obtain, so early application will be necessary. The facility being remediated may have its own unique permits to be obtained prior to starting.

The submittal and approval of these plans and permits is required prior to arriving and starting work at a site. This approval process is an important part of the mobilization process.

PROJECT CONTROLS

The establishment of a project control procedure prior to mobilization should be a requirement of all remediation firms. The control procedure should include the work plan, the project schedule and estimate, and the cost and scheduling monitoring system.

The work plan is sometimes included as one of the early submittals, however it is an integral part of the project control plan. This plan details the sequencing of the work activities for the remediation. Each of the activities are defined with the inter-relationship between them identified. This document is worked closely with the scope of work so that entire remediation effort is covered. The number of work crews and the equipment required are based on the work plan.

As part of the work plan, a work breakdown structure (WBS) of the project is established. The work plan is listed by WBS so the work activities are defined for scope. The WBS is the basis of the activity number for the project schedule and the cost breakdown of the estimate. Progress is monitored for both cost and schedule by the WBS.

The time-phasing of the work plan creates the project schedule which is developed utilizing critical path method (CPM) techniques. The CPM schedule will identify the critical path of activities that the work must follow and finish on time in order for the project to be completed within schedule. The start and complete dates of the activities and float for each will be developed. The development of the project schedule must be completed before the mobilization is started. The schedule activities are coded by the WBS.

The project estimate is developed based on the work scope and plan in conjunction with the schedule. This document will develop the cost of the activities listed in the work plan according to the WBS. Various techniques or approaches can be used for estimating the cost of each activity once the quantity of work has been established. Approaches based on productivity units or crew sizing for the labor cost can be utilized. For the material or equipment pricing, unit prices are developed based on vendor quotations or historical information (including manuals). The actual approach to the estimate is based on the information available, time allowed, and the experience of the estimator.

In developing the estimate, the level of protections must be known for both adjustments to the work productivity and number of crews required as well as for the cost of the personnel protective equipment (PPE). A review of the SHERP will provide the necessary information on the PPE required for each activity. The impacts on productivity due to the levels of protection is one of the main cost drivers for remediation work.

One major part of any remediation estimate is the cost of offsite disposal. For the projects where the wastes are remediated onsite or encapsulated, the cost will be less. However, the offsite disposal may include PPE and other wastes. For other projects such as a drum removal or the removal of contaminated soil, the disposal may be up to 80% of the cost of the work. The development of the estimate for disposal is based on the disposal plan which is developed as one of the early submittals.

The estimate detail will be by WBS so it can relate to the project schedule. The use of the WBS will allow each work activity to have durations, start and complete dates, and costs. This level of information will help in the monitoring of the project. These two documents need to be completed prior to mobilizing onsite.

The integration of the estimate with the accounting and cost monitoring systems will also occur during the mobilization period. The project estimate is allocated into the accounting system WBS (the project's code of accounts). The WBS provides the structure with which the costs will be tracked. The relationship between the schedule and cost monitoring system will allow the costs expended to be related to the completeness of the work. Earned value calculations and performance indexes can be developed using the actual costs and percentage complete of the schedule.

The project control system plan needs to be established prior to mobilizing. The work plan, schedule, and estimate must be completed and budgeted at this time.

PROCUREMENTS

During the pre-mobilization and mobilization periods, procurements of the necessary materials, equipment, and subcontracts are occurring in order for the work to proceed. The timing of the deliveries of these items to the site is an important part of the project and is based on the work schedule.

Prior to the placement of any purchase orders or subcontracts, a review of the terms and conditions of the contract with the client must occur. This review will identify any commercial requirements that must be flowed down to vendors or subcontractors. Examples of these requirements include the

insurance limits, prevailing wage rates, union restrictions, and indemnification. The purchasing agent must include these client dictated terms and conditions in the procurement documents.

The client may indicate what vendors or subcontractors may be used (or not used) on the project and ask for a review of the bid list. The number of bidders for each solicitation may also be dictated by the client.

The first priority will be the procurement of the temporary construction facilities which will be required onsite during the mobilization period. A checklist of typical early construction facilities is included as Figure 1. The trailers required for the project will be procured along with the furniture, utilities, and office equipment.

Decontamination facilities that have to be procured such as wash stations or decontamination trailers will be obtained. Monitoring equipment for the perimeter of the site will be specified and procured at this time. The attached checklist will aid in these early procurements that will be required.

The health and safety supplies that are required for the mobilization and early activities must be obtained. A review of the SHERP and the schedule will identify what PPE and other materials are required early at the site. Other materials may include power washers, wash basins, caution tape or fencing, signs etc. The work can not proceed unless the correct health and safety supplies are at the site.

The construction equipment required for the work is based on the requirements set forth in the work plan and costed in the estimate. The schedule will identify when the equipment is due onsite and the require duration. Whether the equipment is rented, leased, or purchased is usually based on the time required on the site. How the equipment will be used and if it can be decontaminated will assist in this decision.

The work plan and estimate will identify what work will be subcontracted and the scope of each subcontract package. The schedule will state when the subcontractor is due on the site to perform the work. The soliciting of subcontractor bids for the work may occur during the pre-mobilization period but is schedule dependent. However, the project team must know what are the packages with their scopes and estimated values at this time. Early subcontracted services to be obtained during mobilization may include surveyors, drillers, and security.

Offsite services required during the construction will be procured at this time. These services include non-hazardous waste disposal, laundry, sanitary facilities, and temporary office help.

Remediation projects require samples to be taken and analyzed. The awarding of the laboratory work is a major effort during this time period. Also a determination of whether an onsite laboratory would be cost-effective should be performed. Often the client will have pre-qualified laboratories for the work.

If the remediation is to occur outside the firm's normal working area, local contacts have to be made. The establishment of blanket ordering agreement with local material and office supply firms should be set at this time. Credit applications and a bank account will be established.

A successful mobilization and start of a project is dependent on how complete these pre-mobilization procurements are. Checklists, review of the estimate and site visits all aid in the earlier procurements.

ONSITE MOBILIZATION

All the activities described in the above paragraphs usually occur prior to mobilizing onsite. However, the actual moving to the site can present a myriad of activities that have to be completed before the actual site remediation can begin.

The first activity onsite is usually a pre-construction conference with the client's representative responsible for the work. Work restrictions, facility permits, and local building and safety codes will be discussed at this time. If the work is to occur at an on-line facility, plant personnel may be introduced to the remediation team as points of contacts. This meeting may (and should) occur several weeks before moving onsite so permits and other potential problems can be identified and obtained.

The security requirements of clients vary. On-line facilities may require that all workers check in every day. Badges may be required on each worker. Time (and costs) must be allotted for the security restrictions. These requirements are usually listed in the security plan.

Among the first activities on the site will be surveying and the laying out of the site. The "hot" zone will be established and marked by fencing, tape, or stakes. Likewise the contamination reduction zone and the clean areas will be determined at the site. The site security requirements will be enforced at this time based on the layout.

After the zones are laid out, the construction village and decontamination facilities will be constructed. The trailers will be set and utilities established. At some sites, initial sitework might be required prior to setting the construction village. The sitework may include road work, clearing and grubbing, or the setting of perimeter fencing. Gravel can be placed for parking or roadways.

The building of the decontamination facilities is an important part of the site mobilization. These facilities include the cleaning pad for the equipment, the personnel wash stations, the PPE disposal drums, and the "decon" trailer. These temporary facilities must be completed prior to the remediation work initiating.

There are personnel related activities that have to be completed during this mobilization period. Most SHERP's require the onsite workers to receive site specific safety training. This training session can last several days depending on the size of the project. New workers coming to the site at a later date will also have to receive this site specific training. Site personnel may need to have physicals or blood tests in order to work on the site. These initial blood tests will be used as a baseline to verify any contamination that the worker may receive during the remediation process. Many clients and remediation firms require drug tests for the site personnel before they can start work at the site.

The onsite mobilization is the ending of the pre-construction planning and the beginning of the actual remediation onsite.

CONCLUSION

The length and cost of the mobilization period for a project will vary depending on the project's size and remediation technique. For example, the mobilizing of a transportable incinerator may take several months and cost hundreds of thousands of dollars. Mobilization for a small remediation project may only last a few days. This period must be scheduled properly and all activities identified.

All the mobilization activities are inter-related and their completion is required before moving onsite. The early submittals such as the QA plan and SHERP will aid in the development of the work plan which is the basis of the project schedule and estimate.

The estimate and schedule are used to help determine the procurement requirements of the project as to what items are required, their duration onsite, and their quantity. The completion of these procurements is necessary for the onsite mobilization and remediation to proceed.

The estimate also forms the basis of the budget for the project. For a remediation project to be completed within budget, careful tracking of the commitments and expenditures is necessary for management to understand the financial status of the project and to take corrective actions. Coordination between the updating of the schedule and tracking of the actual costs will provide management the tool for this understanding.

Having achieved mobilization within cost and on schedule will not guarantee a profitable and successful project, but it will allow the work to start when and as planned.

FIGURE 1

MOBILIZATION CHECK LIST

PROJECT:
WORK ORDER:
TASK NAME: TASK NUMBER:

SUBMITTALS	RESPONSIBILITY PM	CM	SM	NOTE	ON HAND	SOURCE/COMMENTS
HEALTH & SAFETY PLAN						
WORK PLAN						
DISPOSAL PLAN						
TRANSPORTATION						
ACCOMODATIONS						
PERMITS						
UTILITIES (POWER,WATER,HEAT,SANITARY)						
SAFETY EQUIPMENT PEP						

FACILITIES	RESPONSIBILITY PM	CM	SM	NOTE	ON HAND	SOURCE/COMMENTS
OFFICE TRAILER						
STORAGE TRAILER						
DECON TRAILER						
DRINKING WATER						
FAX MACHINE						
COPY MACHINE						
TEMPORARY STORAGE TANKS						
MANLIFTS						
PHONE(S)						
WALKIE-TALKIES						
FUEL SOURCE/GAS CORD						
FENCING, CONSTRUCTION						
FENCING, SILT						
SECURITY SERVICES						
PUMPS						
DRUMS/OVERPACKS						

EQUIPMENT	NO.	TYPE	RESPONSIBILITY PM	CM	SM	NOTE	ON HAND	SOURCE/COMMENTS
BACKHOE, EXCAVATOR								
DUMP TRUCK								
TRUCK/VAN - PASSENGER								
POWER WASHER								
STEAM CLEANER								
COMPRESSOR								
WET/DRY VAC.								
TEMP. ELEC. EQUIP.								
ROPES								
CAUTION TAPE								
LOCKS								
LADDERS								
DUMPSTER/ROLL-OFF								
NON-HAZ. CONTAINERS								
HAZ. CONTAINERS								
GANG BOX W/ SAWSALL W/ EXTRA BLADES								
GANG BOX W/ SLEDGE								
GANG BOX W/ BOLT CUTTERS								
MECHANICAL HAND TOOLS								
ELECTRICAL HAND TOOLS								
SEE ATTACHED LIST								

NOTE:
NR = NOT REQUIRED
O = OWNER
I = INDIVIDUAL

Construction Disputes On Hazardous Waste Projects

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INTRODUCTION

The purpose of this paper is to provide a framework for the recognition and prevention of potential construction disputes on hazardous waste sites. On many projects accomplished to date, costs have been experienced well beyond those anticipated because of the occurrence of construction claims. Therefore, it behooves all parties concerned with new projects to educate themselves and their staffs such that disputes can be minimized and measures can be incorporated into the contract documents to allow a cost effective method of resolving potential problems.

The objective of this paper is threefold: 1. to assist in the identification of potential problem areas which may create an environment amenable to claims and disputes; 2. to suggest areas where better planning and execution can reduce the incidence of disputes, and: 3. to suggest mechanisms that can be used to allow for prompt and equitable resolution of problems should they occur.

BACKGROUND

All construction projects have the chance of experiencing a claim or a dispute. To understand the nature of disputes, some basic definitions are in order. The first two terms that must be understood are changes and claims.

In all construction contracts, some form of a clause dealing with changes is invariably incorporated. A change in the simplest form is a requirement by the Owner to the Contractor to perform some work which is different from that which is specified in the contract documents. For the time being, we will confine our comments to projects which are design specifications as opposed to performance specifications.[1] In essence, when a contractor bids a fixed price job or even a unit price job, he is bidding to perform exactly what work is specified/defined in the contract documents. The contract documents being the plans and specifications. If the contractor perceives that he is being asked to perform any work which is not specifically defined in the contract documents, then he will request additional compensation in the form of a change order. Thus in the simplest sense, a change is any deviation from the contract documents.

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[1] Design specifications define in detail the work to be performed by the Contractor. There is virtually no design requirements placed upon the Contractor but instead he is required to comply with the detailed requirements specified in the contract documents. In a performance specification, the design is not defined. Instead a Contractor is required to produce an end product which performs in the manner described. In performance specifications, the Contractor does assume a design role. Normally, most hazardous waste projects are not amenable to performance type specifications.

A claim is normally termed a dispute. In essence it is a foul and vile word for a change. If one pauses and reflects for a moment, if the two parties agree that an item is different and a change, they can usually resolve it by change order. It is only when agreement cannot be reached that it becomes a claim. Therefore, a claim is simply an unresolved change order.

Claims occur when a disagreement exists at any of four levels. First, the Owner and Contractor may not agree that a change exists. In other words, while the contractor believes that some work is different than that specified, the Owner or its designer may disagree, asserting that the work is incorporated in the already existing contract documents. Second, the Owner and Contractor may disagree as to the party responsible for the change. In other words a question of liability for the change exists. The Contractor may assert that the change was caused by the Owner, while the Owner believes that the Contractor caused the change situation to occur through some action or inaction of his own. Third, the parties may disagree on the impact of the potential change. For instance, the Owner may agree that a change exists and that it was responsible for it, however, it believes that there is no effect or impact to any of the contractor's work or time on the project. Fourth, the Owner and Contractor may reach agreement on the preceding three points but cannot agree on the costs associated with the change. To summarize these four areas, the following four questions must be resolved:

1. Is it a change - i.e. something different than the requirements of the contract?

2. Who is responsible or liable for the change?

3. What are the impacts of the change?

4. What are the costs of the change associated with the specific impacts?

Disputes on hazardous waste projects may emanate from many sources. While it is impossible for this paper to address all possible sources, the most common ones include, directed changes by the Owner, errors and omissions in the plans and specifications, differing site conditions, and constructive changes. The Discussion section of this paper will elaborate on each of these areas.

As was noted above, most construction contracts are set up to handle changes should they occur. This is done through the changes clause. Similarly, construction contracts recognize the potential for differing site conditions, sometimes termed changed conditions or concealed conditions by incorporating clauses which address these. The astute Owner must recognize that hazardous waste projects are particularly amenable to certain types of changes and concealed conditions and, therefore, must structure the contract to allow as many vehicles as possible to be used to reconcile any problems as they occur. The ultimate goal being the reduction of claims and the avoidance of costly litigation. These areas will also be pursued in more detail in the following sections of this paper.

In order to summarize the diverse areas of disputes in the remaining discussion, the next section of this paper will be organized into the specific sections dealing with: Changes - Directed and Constructive; Differing Site Conditions; and Errors and Omissions. Within each discussion comments will be provided concerning how they can be reduced and also how contractual considerations can help alleviate disputes in each of these areas. Finally, the area of delays and inefficiencies will be addressed since this area generally constitutes the most expensive form of disputes which occur, and can apply to any of the three preceding areas.

DISCUSSION

Prior to a specific discussion of changes and claims, it is worthwhile to pause and reflect on the elements that are unique to hazardous waste projects. As was noted above, every project is susceptible to changes. Hazardous waste projects, however, have risks which are not within the normal experiences. For example, the work environment on the project is different than what most construction personnel are used to. They are working with hazardous materials. Therefore, special and more stringent procedures are followed throughout all operations. As a consequence, a higher level of care and skill must be applied throughout the project. This necessitates better education of the crews and more diligent supervision by the foremen and superintendents.

Construction operations are often conducted very differently than normally pursued. For instance, in an excavation operation, the risks of cross contamination demand a well planned methodical removal method that will not normally yield the same efficiencies one might estimate. Hence, unit costs are higher and must be so anticipated up front.

When designing and estimating a hazardous waste project, all parties must recognize the unique character of the work. Site borings or investigations are a good example of this. Normally, a designer or a contractor will draw conclusions about the site and how the work must be performed based on "representative" borings taken throughout the site. In a normal project this is reasonably reliable since soils follow patterns, seams, profiles, etc. The material at a hazardous waste site, however, was deposited by man in a random fashion. Therefore, despite indications of trends from borings spaced at 500 feet, the material between may vary considerably. Therefore, our entire mind set must change when approaching both the design and the construction of a hazardous waste project.

In assessing the time required to perform work, one must recognize that unanticipated problems may occur and that the more stringent methods of execution will demand longer time durations for activities than normal. Consequently, project and activity durations must be adjusted and understood prior to beginning operations. Oftentimes, delays are not really delays, but merely the reality of the actual time required to perform the work.

Hazardous waste projects are relatively new to the construction arena. Therefore, it is not surprising that Designers, Contractors, and Owner's Representatives are not as familiar with the project and its needs as they would be for more conventional jobs. This lack of familiarity denies them the ability to anticipate and recognize problems and also to resolve them as expeditiously as possible.

Given this understanding, let us now look at the areas that can lead to claims and how we can best control them.

Changes - Directed and Constructive

As was noted above, changes and claims may emanate from many sources. The first item noted was changes which are directed by the Owner. This type of change normally occurs when it is recognized that the Owner desires something to be added to the work which was not originally specified in the contract. A wide spectrum of reasons exists for why this occurs. For example, the Owner may find that the low bid received and awarded is lower than the funds available. Consequently, the Owner may be able to have some additional work performed which was desired but was not considered essential. When the contract documents were created, this work was not incorporated in the interest of insuring that the bids would be within the funding available. Now that the Owner recognizes that the bids are below budget, the decision is made to expand the work by adding those items that were desirable but not originally included.

The Owner may also recognize during the project that some additional work is required that was not originally identified during the project design concept. This is not necessarily an omission but rather a lack of recognition of a need. Regardless of the initiator, the Owner directs the Contractor to perform additional work in accordance with the changes clause.

In order to reduce the chance of changes or claims in this area, an Owner may consider including work in the bid documents in the form of alternates or adds. When an alternate is used, the Owner is not obligated to award the execution of that work. Instead, the Owner awards the base contract work and can award as many of the alternates or adds as it deems appropriate. The Contractor has already submitted prices for each add item, and, therefore, there should be no dispute as to the cost of respective items. The Owner should be cautious, however, that add items are not set up such that one item requires the execution of another add item by virtue of the physical construction parameters involved. As long as that does not occur, no problem should exist.

Another consideration by the Owner, may be to include a contract clause for "If and Where Directed Items". A sample of this type of clause is included at the end of this paper for reference. It is not suggested that this clause be used verbatim. It is included for reference only, and must be written and coordinated with the contract documents as a whole. The random use of "off the shelf" clauses can lead to significant problems in the formulation of a construction contract. Therefore, any ideas gleaned from this paper must be carefully reviewed with the advice of construction counsel. Clauses such as the If and Where Directed clause are particularly amenable to contracts with unit price items. Normally, hazardous waste projects have a significant amount of these items.

In essence, an Owner can reduce the chance of problems vis-a-vis directed changes by carefully considering the amount of work that is necessary, evaluating the importance and benefit of work that is desirable but not mandatory, and structuring the bid and contract documents accordingly.

In setting up contract documents for changes, the Owner should pay particular attention to structuring a changes clause which has a clearly defined method for establishing the cost for the change. By doing this, at the minimum, the fourth area of change resolution - cost - should not create a problem.

The second type of change that creates problems for both parties is known as constructive changes.

A constructive change is a change that is effectively or constructively created by the Owner's action or lack of action. An entire litany of constructive changes exists and have been identified in numerous publications. For the purposes of this paper, a few illustrative examples will be provided such that the reader will understand the concept. If the concept is understood, reasonably any form of constructive change can then be identified. The initial example that will be used is for a constructive change known as "late inspection".

Presume that a contractor is working on a site and as part of the contract requirements must perform some work underground concerning drainage for the site. The drainage requirements specify that the contractor must install a double walled pipe to remove contaminated liquid from one area of the site to a treatment facility in another area of the site. The contract further specifies that before the contractor can backfill the pipe, he must have it inspected and approved by the Owner's representative. Furthermore, the contract states that an inspector will be available within 24 hours notice from the Contractor. Given this background, consider the following scenario.

The contractor excavates for the first 500 feet of pipe. He has placed his bedding and set his pipe and has notified the inspector that he is ready for an inspection. The notification was made at 10:00 am on a Tuesday morning. The inspector, however, does not show up until Thursday at approximately

2:00pm. Given this simple scenario, the four questions which were noted above would have to be considered.

First, is this a change?

Clearly, it is. The contract said 24 hours and the Owner did not live up to this. It is something different than that which was specified.

With regard to the second question of liability, it appears that the Owner is liable since notice was given and the Owner's representative did not comply. Presuming that the Contractor can show an impact to his operations, such as a delay, idle equipment, demobilization and remobilization of manpower, etc., than the third question is answered. If an impact can be defined, than a cost can be associated with that specific impact and all elements of a change order are fulfilled.

In the example described above, a change situation was created by the lack of action of the Owner. Since no revisions were made to the drawings, or no directive was given to the contractor, we do not have a directed change. But we have effectively or constructively created a change to the contract.

Other types of constructive changes, can include such things as:

Requiring a higher standard of performance.

Improper rejection.

Impossibility of performance.

Withholding material information.

The list could go on at length. Rather than attempting to describe all possible constructive changes, the reader must recognize that the action or lack of action of the Owner can lead to these types of changes. In order to prevent them, the Owner should insure that its staff is educated in the area of constructive changes, and the types and nature of them. Also, the Owner's staff must understand its obligations under the contract and fulfill them such that no assertion can be made that a constructive change occurred.

The results of constructive changes can be varied. The majority of the time, these types of changes will lead to either extra work, delays, or inefficiencies. If the contract is heavily weighted on unit price items, then the recommendation concerning the If and Where Directed clause would apply in this circumstance. For delays and inefficiencies, suggestions will be provided later in this, discussion under that specific topic.

It has been the author's experience that constructive changes that occur on hazardous waste projects are caused many times by lack of experience on hazardous waste work. For example, remediation projects that specify excavation and disposal are often managed by personnel with a background in heavy or horizontal construction (as opposed to vertical construction). While this certainly is appropriate, it may still be short of the more significant requirement of experience with hazardous waste. Excavation and backfilling on a dam while conceptually similar, may be markedly different in actual execution on a hazardous waste site. Therefore, additional training and education should be considered for the personnel to be employed in the construction resident roles. As an example of how a lack of understanding can create a problem, consider the following.

During the excavation of a landfill area on a military base, the Contractor uncovered some unexploded ordnance. On the first two occurrences of this, the Owner negotiated a method and price for removal and a bilateral change order was executed. Shortly thereafter, however, more "live rounds" were discovered. The ordnance ranged from small arms rounds to 500 pound bombs. The Owner directed the Contractor to develop and submit a unit price for the removal of all ordnance regardless of the type. This ultimately led to delays and numerous disputes over the actual cost of removal.

Differing Site Conditions

Differing site conditions, concealed conditions, or changed conditions are a very common problem in hazardous waste projects. This occurs because most projects deal with either underground or buried conditions or deal with items that are behind walls, in ceilings, etc. Hence, the chance for hidden or unforeseen conditions is enhanced.

Generally, differing site conditions are divided into two types, Type I and Type II.

Type I differing site conditions are those which occur because what actually exists at the site differs materially from the representations made in the contract documents. For example, a recent project for removal of hazardous waste at an abandoned landfill had contract documents that reflected the presence of several Key Indicator Compounds (KICs). While the compounds were clearly defined and the anticipated levels of concentrations specified, certain compounds were not included since the investigation by the designer did not show their presence. In particular, PCBs were not included in the KICs and the Contractor reasonably would not have anticipated their existence. The original studies for the project appeared to be thorough and showed only trace amounts of PCBs, such that no remediation for them would be anticipated. In reality, the excavation and testing by the Contractor during the remediation revealed extremely high concentrations of PCBs such that the material excavated from the site had to be disposed of at landfills which would accept PCBs but which were never anticipated by any of the parties nor in the contract. As a consequence, the Contractor was required to perform extra work, was delayed in the progress of his work, and also experienced a high degree of inefficiency in the excavation, testing, and disposal operations. This was a Type I differing site condition. What was encountered was materially different than that which was represented by the contract documents.

A Type II differing site condition exists when material is discovered which is unusual or unexpected and would not normally be anticipated for that type of work in that location. This type of differing site condition occurs very seldom, but is noted so that the reader will have a more complete reference concerning differing site conditions.

In order to reduce the incidence of concealed conditions, the Owner is well advised to not be miserly during the site investigation phase of the project. Oftentimes a few more borings and a more diligent investigation of the facilities will uncover items that may not otherwise be noted and could lead to changes and claims later on during construction.

A second consideration again is the use of the If and Where Directed clause. A third consideration is to have the contractor perform site investigations as a first phase of a multi-phase contract with the option of not continuing after the initial phase if conditions warrant a reconsideration of the project parameters.

It is not recommended that the Owner attempt to protect himself by the use of exculpatory clauses such as a "don't rely on the borings" type of clause. While these clauses may have some degree of legal

enforceability, they may still initiate litigation, in which case nobody wins - except maybe the attorneys.

In performing site investigations, the Owner may consider an independent firm from that which is providing the design services. In the alternative, the Owner may use a second firm to run a check on the investigations performed by the design firm. While some may feel that this is a needless expense, money up front is usually cheap in the long run.

A final consideration with respect to the contract documents would involve the use of a variations in estimated quantities clauses. This type of clause is set up to allow a contract adjustment if quantities for a specific unit price item experience a significant overrun or underrun during the actual project. A sample of this type of clause is included at the end of this paper. Once again it is recommended that the structuring of the specific clause be prepared with the assistance of qualified construction counsel. By having such a clause, the Owner may reap the benefit of reduced costs for overruns, and equity would be afforded the Contractor for underruns such that fixed costs may be covered.

Errors and Omissions

The final area that will be noted involves that of errors and omissions in the plans and specifications. This is a delicate subject and one that most designers do not like to discuss.

An error or omission basically is a mistake in the contract documents made by the design engineer. Merely because an error or omission exists does not mean that the designer is liable for any increased costs. Let us address the two items separately.

An omissions is just that. An item of required work was not included in the contract documents. The contractor, Owner, or designer may note this during the execution of the project and a change order would follow. Hopefully, the change can be resolved through the mechanisms set up in the contract with no cause for dispute. Oftentimes, however, this does lead to a dispute because the designer is alarmed that the Owner will assert that he should pay for the omission. Generally, this is not reasonable. If the designer had included the item in the contract documents originally, the bids should have been correspondingly higher and, thus the Owner would have paid for the work anyway. Since it is now being added as a change, the Owner has not been charged for anything extra or for a mistake. To require the designer to pay for the omission would really be giving the Owner something for nothing or in more technical terms, the Owner would be unjustly enriched. The only caution that should be noted is that if the cost of the work is higher because of the omission than it would have been if included in the original documents, then the designer may be liable for the difference in the costs. This then would became a question of design negligence which is also the basic premise for errors.

An error is simply a mistake made in the contract documents. No set of contract documents are perfect. Some degree of errors should be expected. For that reason owners are encouraged to allow for some contingency in their budget. The important question is when does an error become the responsibility of the designer and not the Owner?

Basically, the designer becomes liable for an error if it can be shown that the error resulted from not applying the standard of care which is normally anticipated for that type of design work in that part of the country. This is almost always a question of expert opinion and the Owner should be cautious not to embark on a costly witch hunt without seeking help from qualified independent personnel. If, indeed it can be shown that the error is negligence on the part of the designer, than the Owner would be entitled to compensation from the designer.

In the area of errors and omissions, the Owner is cautioned not to be too aggressive with the designer. This does not mean that the Owner should not pursue problems that legitimately are the liability of the designer. What it does mean is that if the Owner looks to the designer for every small problem that occurs, the designer will attempt to push every possible change back into the Contractor's lap. The positions taken include things such as:

"A knowledgeable contractor should have known that it was the intent of the contract documents."

or

"The contractor should have discovered that problem during their site visit."

or

"It may be a problem, but there was no real extra costs for the contractor."

In all of these responses, the contractor is then forced to make a claim against the Owner and a dispute ensues. If need be, the Owner may seek independent review of the changes in order to ascertain if changes do exist and the impact and respective costs.

The final area that will be addressed is that concerning delays and inefficiencies.

Project delays can lead to huge disputes with significant cost ramifications. While this area has been the subject of numerous articles and books, only a few brief comments will be offered here.

To reduce the chance of problems with delays on a hazardous waste project, the Owner should require and maintain a thorough and detailed construction schedule for the entire job. It is strongly suggested that the Owner require a Critical Path Method (CPM) schedule and that it be updated throughout the project at reasonable time intervals, such as monthly.

Despite the use of a good CPM schedule on the job, delay claims may still arise. To reduce the amount of disputes in this area, the Owner may consider a specific clause dealing with specified amounts of compensation for the contractor should delays occur. A sample of this type of clause is also included at the end of this paper. Once again, the reader is cautioned that the clause must be developed for your specific project with the assistance of qualified construction counsel.

Finally, in the area of delays, if it is determined that a contractor is delayed during the job and is entitled to a time extension, the Owner is wise to grant the time extension rather than attempt to put it off until the end of the job. Delaying the time extension decision can lead to other compounding claims on the project and an even bitter and more costly dispute.

The area of inefficiency is similar to the area of delays. Normally inefficiency claims arise because of changes, differing site conditions, delays, etc. In essence, the Contractor is claiming that its operations were not performed as efficiently because of one of these causes and requests additional compensation for its work. An example of this would be the following.

In a recent hazardous waste project, the contractor encountered hazardous wastes on a haul road on the project. The contract documents represented that no hazardous materials would be anticipated in this area. This differing site condition required the contractor to construct a new haul road for the bulk of the excavation work. As a consequence, the distance for hauling was significantly increased and the unit cost of the excavation was increased. In other words, the contractor's excavation operations did not proceed as efficiently as he could reasonably have planned based on the contract

documents. This problem could have been resolved when the situation was first identified. Instead, the Owner attempted to deny the differing site condition and compounded the dispute. Furthermore, the Owner did not maintain good records on the remaining excavation and was at the mercy of the contractor's records to document the impact to the operations.

A question the authors are commonly asked is what type of problems should be expected on a hazardous waste site. Unfortunately it is not easily answered. In general, one should anticipate the absolute application of Murphy's Law - if something can go wrong, it will.

It is impossible to list all types of problems that could occur. The project planner must discipline himself to reflect on the nature of the job and the vagaries of the site. Based on this, a list of all potential problems should be developed along with possible solutions to those problems. In that manner one is better prepared to handle problems should they occur.

Examples of problems that have been observed cover a broad spectrum. For example:

1. In the excavation and removal of hazardous wastes, huge overruns of contaminated material were experienced. Though on a unit price basis, the Contractor experienced significant cost increases for several reasons. First, the receiving landfill had daily limits. As a consequence, the Contractor had to find a second approved landfill at a greater distance from the site and at an increased cost. Second, the testing, stockpiling, processing, and hauling was dramatically changed because of the volume of material. This also affected the unit cost.

2. During a clean up of an existing toxic landfill site, an underground spring was discovered. Once the pit was opened, the spring fed water through the site. This created a large volume of contaminated water that had to be treated and increased the cross contamination on the site.

3. During remediation on a government facility, live munitions were discovered in the excavation process. This effectively changed the entire nature of the job.

4. In the remediation of a site, the Contractor was required to segregate non-contaminated material and replace it after the contaminated material was removed. When this began, it was discovered that the material would not compact as normal soils would. Hence, the final ground elevation was higher than planned which affected the placement of fabric covers and the hydrology of the site.

CONCLUSIONS

While many ideas can be gleaned from the problems that have already occurred on hazardous waste projects, the following major points summarize the thrust of this paper.

1. Prepare good complete contract plans and specifications such that the incidence of errors and omissions are reduced and hence the incidence of changes and claims. If possible, have an independent review of the contract documents prior to the bid letting. This review should be performed by an organization other than the project designer and should focus on the completeness of the documents and the constructability of the project overall. Even with this effort it is likely that some errors and omissions will occur.

2. The Owner should go the "extra mile" to make sure that detailed site investigations are performed to reduce the chances of differing site conditions. Money up front is cheap in the long run.

3. The Owner and its representatives must be educated in the area of constructive changes and must understand their obligations under the contract. By doing this, the occurrence of constructive changes will be reduced. Also, if constructive changes occur, they will be resolved more quickly.

4. If an Owner recognizes that some work is desired but may have to be excluded due to funding limitations, consideration should be given to add or alternate items in the bid documents.

5. Drafting of the contract documents should include consideration of such items as If and Where Directed clauses, Variations in Estimated Quantity clauses, and clauses dealing with allowable costs for delays. The contract as a whole should be reviewed by qualified construction counsel. This review should not be made with the intent of "sticking it to the Contractor" but rather in structuring equitable clauses that will reduce the chances for disputes and will incorporate mechanisms that can help resolve them should they occur.

SAMPLE CLAUSE

"If And Where Directed" Items

The Proposal Form may request bids on one of more Pay Items to be incorporated into the Project "if and where directed" by the Engineer. The Engineer shall have sole discretion in determining whether and to what extent such items will be incorporated into the Project. Incorporation of such items into the project shall only be made on written directions of the Engineer. In the absence of written directions, no such items shall be incorporated into the Project and if incorporated shall not be paid for. The Engineer may order incorporation of such items at any location within the contract and at any time during the work. These items will not be located on the Plans. The estimated quantities set out in the Proposal for such items are presented solely for the purpose of obtaining a representative bid price. The actual quantities employed may be only a fraction of, or many times the estimated quantity. The Contractor shall make no claim for additional compensation because of any increase, decrease or elimination of such items.

SAMPLE CLAUSE

Variations in Quantities

Unit cost adjustments based on increases or decreases in contract quantities will be considered only for an increase in excess of 125 percent or decrease below 75 percent of the original contract quantity. Any allowance for or against the contractor on account of an increase in quantity shall apply only to that portion in excess of 125 percent of the contract quantity, or in case of a decrease below 75 percent to the actual amount of work performed.

SAMPLE CLAUSE

Compensation For Project Delays

COMPENSABLE DELAYS - The Owner will provide an equitable adjustment to the Contractor only for delays created by the Owner's acts or omissions. Unless otherwise specified, the Contractor assumes the risk of damages from all other causes of delay.

The term "delay" shall be deemed to mean any event, force or factors which extends the Contractor's time of performance of the Contract. This Subsection is intended to cover all such events, actions, forces or factors, whether they be styled "delay", "disruption", "interference", "impedance", "hindrance" or otherwise.

Strict compliance with the provisions of this Subsection will be an essential condition precedent to any equitable adjustment for delays.

Only the additional costs associated with the following items will be recoverable by the Contractor as an equitable adjustment for delay:

a. Non-salaried labor expenses.

b. Costs for materials.

c. Equipment costs.

d. Costs of extended job-site overhead.

e. An additional (10 Suggested) percent of the total of items a, b, c, and d, for home office overhead and profit.

All costs claimed must be adequately documented when measuring additional equipment expenses (i.e. ownership expenses) arising as a direct result of a delay caused by the Owner, do not use in any way the Blue Book or any other similar rental rate book. Use actual records kept in the usual course of business,and measure increased ownership expenses pursuant to generally accepted accounting principles.

The parties agree that, in any adjustment for delay costs, the Owner will have no liability for the following items of damages or expense:

a. Profit in excess of what provided herein;

b. Loss of profit;

c. Labor inefficiencies;

d. Home office overhead in excess of that provided herein;

e. Consequential damages, including but not limited to loss of bonding capacity, loss of bidding opportunities and insolvency;

f. Indirect costs or expenses of any nature;

g. Attorneys fees, claims preparation expenses or costs of litigation.

Comparative Roles of the Environmental Protection Agency and the Bureau of Reclamation During Construction and Implementation of the Lidgerwood, North Dakota Superfund Project

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INTRODUCTION

The Lidgerwood Project is one of three remedial actions which constitute the on-going cleanup at the Arsenic Trioxide Superfund Site (Site). As the lead agency throughout the Remedial Design and Remedial Action (RD/RA) phases of the Project, the U. S. Environmental Protection Agency (EPA) was responsible for the coordination of all activities related to the Lidgerwood Project. Through two Interagency Agreements (IAG), the U. S. Bureau of Reclamation (BOR) was "contracted" by EPA to develop the RD and perform direct procurement and construction oversight of the RA activities on behalf of EPA.

Through a cooperative team effort with EPA, BOR issued the specifications, awarded the contract, and completed construction for the Lidgerwood Water Treatment Plant Facility (Plant) as scheduled. While the opportunities for conflicts and problems during RD/RA were myriad, only those which were of major impact to the Lidgerwood community, construction completion, or funding are documented in the following discussion. Many of these pertain to notification issues, reimbursement of EPA funds, cost overruns, and recycling concerns. Suggestions based on the practical "hands-on" knowledge gained from the Lidgerwood Project are offered for consideration to individuals and "teams" who may be initiating or conducting RD/RA at other Superfund sites.

BACKGROUND

The Site consists of 20 townships which encompass approximately 500 square miles in the southeastern corner of North Dakota. The Site area is composed of sparsely populated farmland interspersed by small communities such as Lidgerwood. Approximately 4,500 people live within the Site area, of which an estimated 1,000 reside within Lidgerwood. Lidgerwood serves as a trade center for the surrounding agricultural area and provides commercial enterprises such as implement, chemical, and seed dealers, as well as grain elevators.

The Site topography consists of gently rolling hills and flat plains shaped by past lakes and glaciers. Ground water in the region is composed of unconfined glacial drift aquifers, as well as the deeper Dakota Sandstone Aquifer. Heavy grasshopper infestations of agricultural crops in the 1930's and 1940's resulted in widespread and frequent applications of arsenic-based pesticides. It is estimated that more than 165 tons of arsenic contained within grasshopper bait were spread throughout the Site area during this period. In 1979, routine sampling of ground water, as required by the Safe Drinking Water Act (SDWA), discovered that the water supply for the City of Lidgerwood (City) exceeded the Maximum Contaminant Level (MCL) for arsenic.

The Site was placed on the National Priorities List (NPL) in September 1983 and the Remedial Investigation and Feasibility Study were completed in 1986. Elevated levels of arsenic, exceeding or approaching the MCL of 0.05 milligrams per liter (mg/L), were identified in Wyndmere, Rutland, and portions of the surrounding rural areas. Arsenic contamination at the Site appears to have been limited to seven major glacial drift aquifers within the region. A Record of Decision (ROD), signed in September 1986, excluded the Cities of Lidgerwood and Wyndmere because their respective water treatment plants already provided effective removal of arsenic from the ground water. Further investigation of the Lidgerwood Plant was approved as a result of operational problems which plagued the Plant after the first six months of operation. These analyses contributed to the inclusion of the Lidgerwood Plant in the Arsenic Site in a ROD supplement dated February 5, 1988.

The Site area and Project location are illustrated in Figure 1. EPA also refers to the Lidgerwood Project as Operable Unit II, Remedial Activity 1.

PROJECT HISTORY

The Lidgerwood Plant was designed, constructed and brought into operation in late 1985 to remove arsenic, iron, and manganese from the ground water. The original Plant was a single story, prefabricated structure with dimensions of 32 feet in length and 28 feet in width. It consisted of a packaged aeration, detention, and filtration system; a concrete clearwell and backwash water recovery sump located below the operating deck; service/backwash pumps; and the required appurtenances to manually operate the Plant.

As originally designed, the Plant treated the contaminated ground water pumped from City wells to provide the City's water supply. The treatment process involved oxidation by aeration and the addition of potassium permanganate, followed by addition of a polymer to enhance flocculation of the suspended particles within the detention basin, and finally sand filtration. The removal of arsenic occurs as a result of incidental coprecipitation with the iron. Following treatment, the water was pumped to an elevated water storage tank from which water was gravity-fed into the distribution system. Filters were backwashed on an as-needed basis by utilizing treated water stored in the facility's clearwell. Specific details of the original Plant design and operation procedures are clearly documented in the **Design Summary Report** (EPA, 1989a).

After an initial six months of acceptable Plant performance, operational difficulties developed and the Plant was reported to have been down as much as 70 percent of the time prior to intervention by the EPA in October 1988. At times, the Plant produced "pink" or "brown" water which indicated an excess of unreacted permanganate or an excess of unreacted manganous ion, respectively. Periodically, product water failed to meet one or more of the SDWA criteria. During periods when the Plant was not functional, untreated water was delivered directly to the City distribution system.

The operational difficulties experienced by the Plant resulted in elevated arsenic, iron, and manganese concentrations in the distribution system. Under the SDWA, arsenic is regulated at an MCL of 0.05 mg/L. This primary drinking water standard is enforceable and based upon adverse health effects.

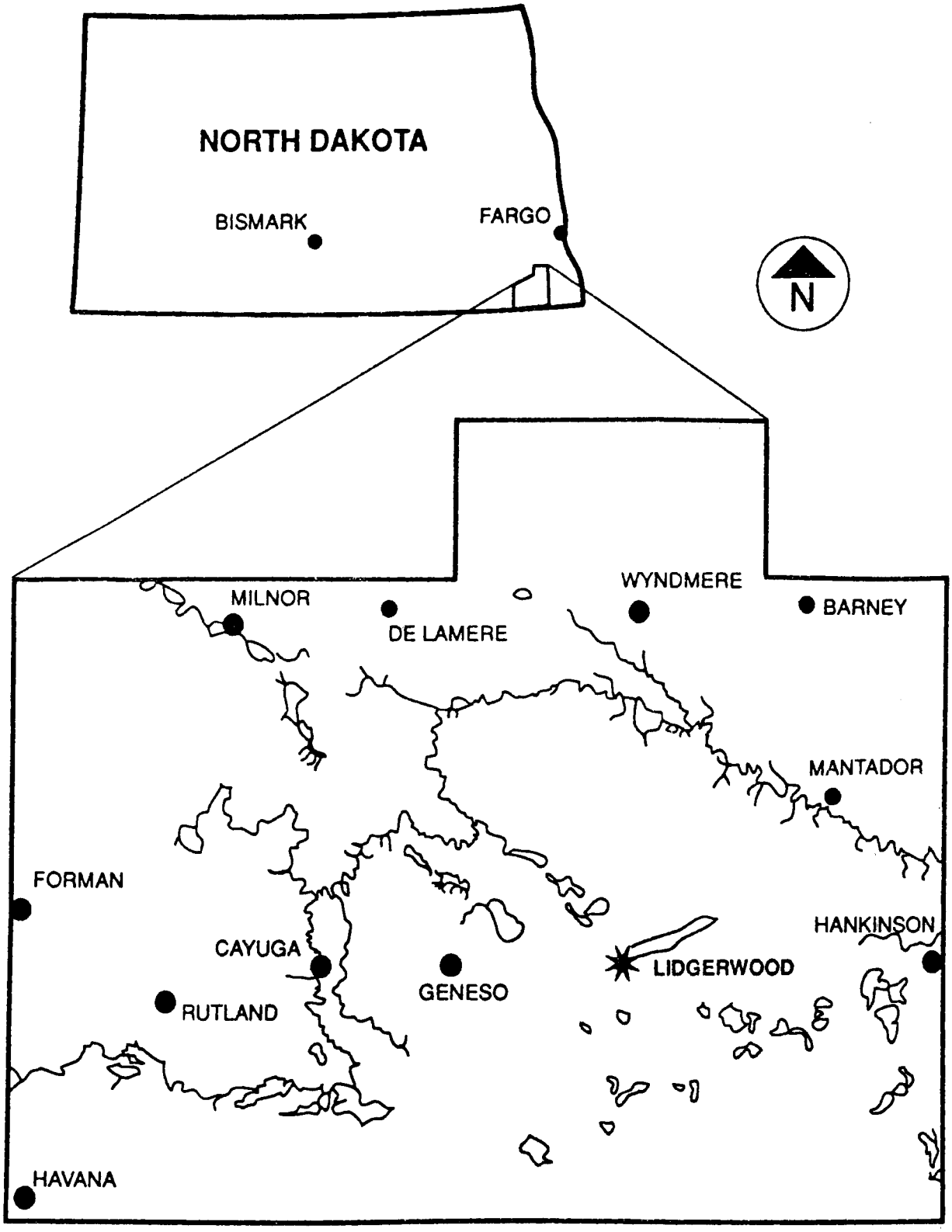

Figure 1 -- North Dakota Arsenic Trioxide Superfund Site Area and Lidgerwood Project Location

Non-enforceable secondary drinking water standards exist for both iron (0.3 mg/L) and manganese (0.05 mg/L) based upon "taste and staining." Because the MCL for arsenic in the untreated water was exceeded, the Lidgerwood Plant was included as part of the Arsenic Trioxide Superfund Site.

Many of the Lidgerwood residents did not perceive the arsenic concentration to be a problem since there was no associated difference in the color, smell, or taste of the ground water when compared with "safe" drinking water. However, the occurrences of pink or brown water did cause residents to become concerned about potential health threats from the addition of chemicals by the Plant to the treated water. The inability of the Plant to function properly had also led residents to consider it as an experimental facility, and their trust and confidence in "the Government" to resolve the operational problems and complete the Lidgerwood Project had steadily decreased. The residents generally felt that the Plant was an unnecessary and wasteful project which had been forced upon them, at an average cost of $1,000 per residence, by "the Government."

EMERGENCY RESPONSE ACTION

In February 1988, the selected remedy for the Site - which included expansion of an existing rural treatment system, continued monitoring, and institutional controls - was formally extended to include the Lidgerwood Project. EPA selected modification of the Plant including automation of the backwash system, increasing the existing potable water storage and treatment capacity, and reimbursement of the City's construction costs as the most cost effective long-term alternative for remediating the elevated concentrations of Lidgerwood's drinking water. In October 1988, EPA initiated an Emergency Response Action at the Lidgerwood Plant in response to the Plant being shut down over an excessive period of time. Through an IAG, the BOR was initially "contracted" to develop and implement immediate measures which would make the Plant operational and capable of providing safe drinking water to the community.

At a meeting held in October 1988, the Plant's operating history was reviewed; problems identified; and a plan of action determined. The problems which were identified consisted of: high backwash frequency, poor filter media performance, clogged filter underdrain nozzles, and disposal of backwash water including sludge and precipitates. The immediate solution, proposed by the City, included removal and replacement of the filter media, replacement of the filter underdrain nozzles, and transport of the backwash water to the City sewage lagoon. An action memorandum issued by the EPA On-Scene Coordinator (OSC) in December 1988 specified the nature of BOR's role during the emergency response period. The initial BOR involvement was to include:

1. Technical guidance on rehabilitation of the filter media;

2. Recommendations of methods to handle the backwash water including the sludge;

3. Review of the original Plant design and operation and technical assistance regarding the Plant modifications proposed by the City's architect/engineer; and

4. Training the Plant operators.

After the first meeting in October 1988, BOR assisted in replacing the filter media and underdrain nozzles. At the same time, a General Filters Company customer service representative was at the Plant to "activate" the proprietary coating to the new media. In addition, the representative changed the potassium permanganate feed point, recommended the use of a different polymer, and provided Plant start-up services.

The Plant returned to operation on November 10, 1988. Results of the first effluent sample showed that the arsenic level had been successfully reduced from 0.118 mg/L to 0.017 mg/L, which is well below the MCL of 0.05 mg/L. By June 1989, there had been three documented excursions of purple water in the clearwell since the November 1988 startup. Additionally, there were 18 upsets of pink water in the clearwell, one upset of overdosing of polymer, and one flooding of the backwash recovery sump. Frequent backwashing was required due to built-up head losses. Subsequently, the backwash water had to be hauled to the sewage lagoon as often as every other day. Approximately four hours of intensive work by the operators was required on a daily basis to maintain acceptable treatment capabilities of the Plant.

ROLE DEVELOPMENT

Subsequent discussions in December 1988 between the EPA and the North Dakota State Department of Health (State) resulted in the designation of EPA as lead agency for the RD/RA phases of the Lidgerwood Project. During this time, the EPA Project Manager was responsible for coordination of all activities for the Lidgerwood Project. These included direct conduct of Community Relation activities; development and oversight of various interagency documents with the State, the City, and BOR; and related responsibilities concerning funding for the Project. These multiple coordination/lines-of-communication are discussed in detail below and illustrated in Figure 2.

City and State Involvement. A three-party agreement, known as a Superfund State/Political Subdivision Contract (SS/PSC), between EPA, the State, and the City was mutually negotiated and signed in March 1989. This document delineated the roles and responsibilities of each party and provided for direct coordination between EPA and the City. A Cooperative Agreement (CA) also signed in March 1989 awarded funding to the City for their participation in oversight of the Project.

Community Relations Development. In an effort to address the Lidgerwood community's strong discontent which centered upon the non-functioning Lidgerwood Plant, a Work Assignment (WA) was allocated to CH2M Hill to update and revise the existing Community Relations Plan (CRP). Interviews with representatives from the Lidgerwood City Council and community members were conducted in August 1989. The primary interest identified by the interviews was a strong desire to see the treatment plant operate as it was intended without spending additional funds. Health issues resulting from episodes of colored water, related financial issues, and Project information needs of the community were also identified. It was determined that biweekly updates which would describe the on-going and anticipated construction activities would be published in the weekly **Lidgerwood Monitor** newspaper during the active construction period. It was believed that the updates, in association with the actual modifications, would best address the issues which had been identified.

Remedial Design Summary. Because the BOR was already on-site for the Emergency Removal and had done a preliminary analysis of the Plant's inability to operate correctly, it was determined that the most expedient method for design and implementation of the Plant modifications was to have BOR follow through with development of the RD. Due to the serious nature of the situation, an accelerated design and construction schedule was established by EPA and BOR as follows:

Concept RD (30 percent complete) -- February 1, 1989.

Final RD Approved -- March 31, 1989.

Invitation for Bid -- June 6, 1989.

Bid Opening -- July 14, 1989.

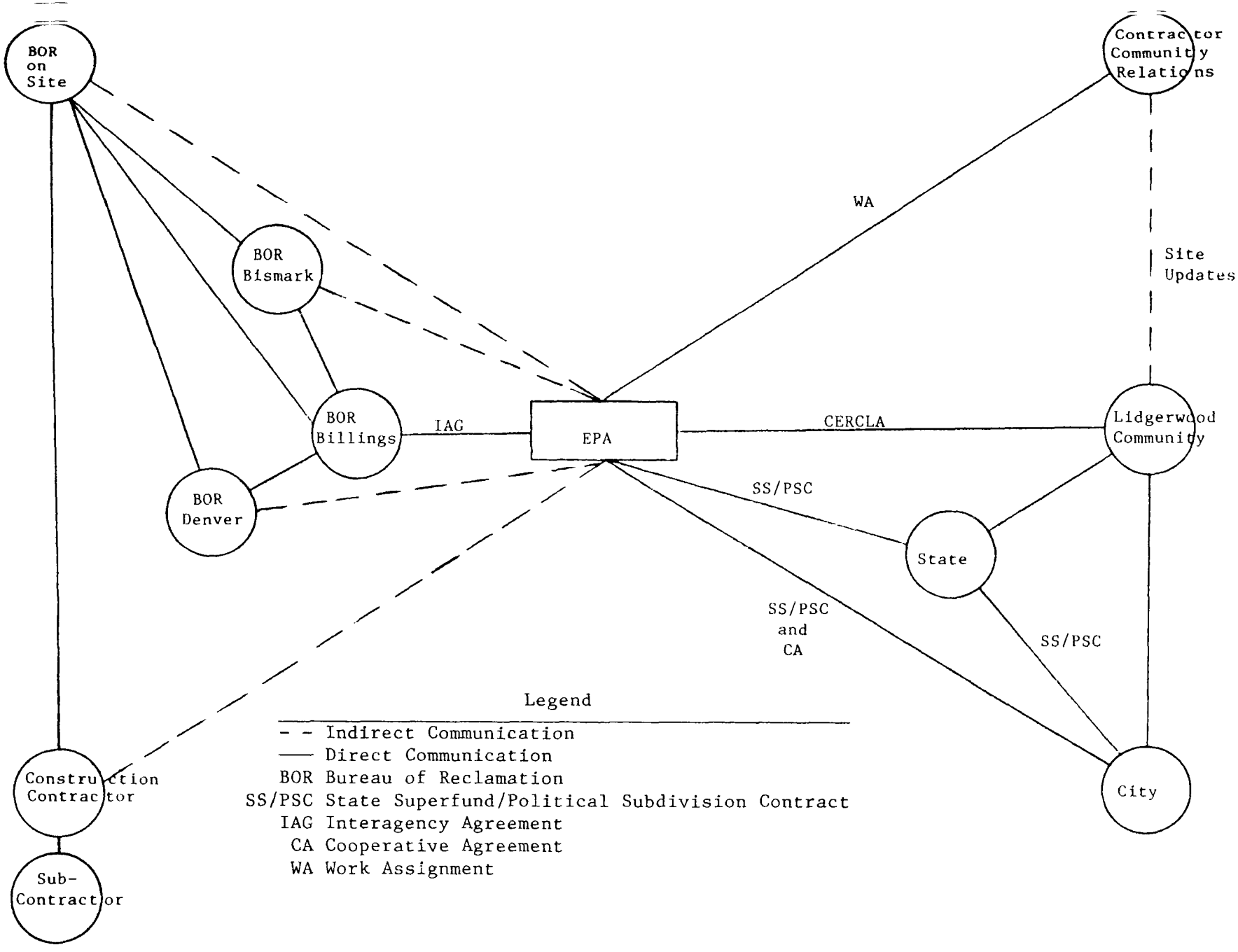

Figure 2 - - Lidgerwood Project Team Coordination Schematic

Bid Award -- August 15, 1989.

Construction Complete -- January 30, 1990.

As part of the RD process, various laboratory investigations were conducted by BOR to determine if the Plant's chemical process for the removal of arsenic and the accompanying iron and manganese could be made more reliable and effective. Changes in the equipment and operation of the Plant were proposed by BOR and subsequently incorporated in the Lidgerwood RD based upon the results of these investigations. These changes and the investigation results are documented in the Lidgerwood **Modification Design Report** which was first published in June 1989 (EPA/BOR, 1989). The investigation tasks and their respective analytical interpretations are summarized in Table 1.

In general, the Plant was originally designed to:

- Oxidize ferrous iron to ferric hydroxide;
- Oxidize manganous irons to manganese dioxide;
- Add polymer to aid in the precipitation process;
- Filter for the removal of precipitates;
- Chlorinate to inhibit microbiological growths and leave a residual for disinfection; and
- Remove arsenic trioxide by co-precipitation with iron.

The original Plant had a treatment capacity of 252 gal/min. Based on the review of operational records, consultants' reports, on-site inspection, manufacturer's review, and laboratory analyses by BOR during Phase I, several problems were identified. The RD modifications consisted of removing some of the alterations which had been made to the original Plant design by the City in its attempts to make the Plant operate properly, and the addition of equipment which would ensure that the Plant could consistently deliver water which met the current water quality criteria with respect to arsenic content. A 28-by-28 foot building addition would house additional equipment including an enlarged detention tank that would provide an additional hour of detention to the water following permanganate addition, a second clearwell which would increase the clearwell capacity by 25,000 gallons, a stirrer to ensure proper mixing of the permanganate and polymer, two backwash pumps of proper capacity and head, motor operations and controllers to automate the backwash process, analytical equipment to allow the operator to measure iron and manganese concentration of the finished water on-site, and a disposal trench system to percolate the filtrate from the backwash water sludge. Specifically, the modifications to the Plant were incorporated in the RD as follows:

1. Mixing - The plenum under the existing aerator was converted into a rapid mixing tank. This improved mixing of polymer and potassium permanganate to obtain a more thorough chemical reaction. A 1.0-hp mixer was provided to accomplish the mixing.

2. Backwashing and Automation - The existing Plant required frequent backwashing, often on a daily cycle. The backwash process reduces Plant production time which depletes the amount of filtered potable water potentially available to the community. Also, a substantial amount of product water is used during backwash, thereby, reducing the amount of potable water provided to Lidgerwood even further. A new process was designed to reduce backwash frequency. Two properly sized backwash

Table 1 -- Laboratory Investigation Tasks and Analytical Interpretation

TASK	CONCLUSIONS
1A Reaction Times - Oxidation Using Potassium Permanganate ($KMnO_4$) of Manganese (Mn) and (Fe) with associated Removal of Arsenic (As)	1. Fe and As precipitate out of solution in about 20 minutes in a very fine, poor Iron settling floc. 2. Detention time of 60-90 minute produces water with acceptable Fe, Mn, As levels and a suitable floc size.
1B Effect of Polymer Addition on Removal of Iron, Manganese, and Arsenic, and on Floc Development	1. The addition of Percol LT-20 (polymer) produces heavier, more filterable and better settling precipitate. 2. Lag time between $KMnO_4$ and polymer addition is not significant.
1C Effect of Newly Activated Sand on Iron, Manganese, and Arsenic Removal	1. Newly activated sand is effective in removing both manganese and arsenic from water treated with permanganate. 2. Iron precipitates before it reaches the activated sand.
1D Effect of Adding Ferrous Chloride ($FeCl_2$) on Iron, Manganese, and Arsenic Removal	1. The higher the iron content in raw water, the more effective the $KMnO_4$ is in removing arsenic. 2. $FeCl_2$ aids in coagulation, but is less effective than polymer.
1E Testing of Effects of Miscellaneous Variables on Iron, Manganese, and Arsenic Removal	1. Lower reaction temperatures hinders Mn removal, but do not substantially reduce Fe or As removal. 2. Cl_2 is less effective than $KMnO_4$ in Fe-As removal. 3. Seeding does not significantly enhance Fe-As removal. 4. Arsenic tends to reenter solution with time, see (1F).
1F Effect of Extended Holding Times (up to 12 weeks) on dissolution of Arsenic, Iron, and Manganese	1. Fe and Mn concentrations were undetectable during the test periods. Soluble As in the test water did not change significantly during the 12 weeks.
2 Total Organic Carbon (TOC) Sulfide in Lidgerwood Raw Water	1. The TOC of the raw water was found to be 2.8 mg/L. 2. Sulfide in the raw water was less than the detectable limit of 1.0 mg/L.

Table 1 -- Laboratory Investigation Tasks and Analytical Interpretation

TASK	CONCLUSIONS
3A Settling Rates of Oxidation Products	1. Precipitate currently produced at the Plant is very fine and light, resulting in slow settling characteristics and a low percentage of solids.
3B Settling Rates of Sludge	1. Aged sludge settles well in lower layer; from 0.145 percent solids to 1.74 percent after one hour and to 4.17 percent after 48 hours. 2. Long settling times improve solids level to 4.54 percent after three weeks, including weekly resuspension.
4A Chemical Oxidation Demand (COD) in Lidgerwood Raw Water	1. Although initially scheduled for analysis, COD tests were subsequently determined to be unnecessary.
4B Analysis of Coating on New Activated Sand	1. Activated coating on new sand is 0.40 iron, 0.027 manganese, 0.0004 arsenic, as weight percent of total sand. 2. Characteristics of new sand coating appear similar to greensand.
4C Analysis of the Scale on Flow Nozzles	1. Nozzle scale contained 38 percent iron, 0.29 percent manganese, and 0.01 percent arsenic. 2. Scale buildup in the nozzles was probably caused by faulty backwash procedures.
4D Analysis of Coating on Used Sand	1. Activity of sand appears to diminish with filtration cycles. 2. See Task No. 8 for further studies on effect of filtration cycles on activated sand.
5A Sludge Dewatering Study	1. Sludge bulk volume can be reduced significantly by a filter press. 2. Dry weight percent of sludge was found to be 3.4 silica, 7.4 manganese, 29.3 iron, 20.6 calcium, 2.4 arsenic, 36.0 sulfate salts.
5B Lidgerwood Water Treatment Plant Sludge Studies (National Sanitation Foundation)	1. The National Sanitation Foundation decided not to characterize Lidgerwood Water Treatment Plant sludge at this time.

Table 1 -- Laboratory Investigation Tasks and Analytical Interpretation

TASK	CONCLUSIONS
6A Proposal to Replace 6-in of Activated Sand in One Filter Cell with Anthracite	1. An anthracite top layer would result in longer activated filter runs because of deeper bed penetration of the precipitate. 2. Anthracite will reduce the plugging tendency of upper part of filter bed by polymer.
6B Proposal to Replace Activated Sand in One Filter Cell with "Greensand"	1. The surface of activated sand is chemically similar to commercial greensand. 2. Equal volumes of greensand have many more active sites than activated sand.
7 Operator Training in Process Water Sampling and Chemical Handling	1. Poor analytical procedures and chemical feed rate adjustments. 2. Handling and storage of chemicals are messy and unsafe.
8 Effect of Process Cycles on	1. Lidgerwood "Activated" sand has some properties of greensand. 2. Particle size distribution is not affected by backwash. 3. Most precipitated particles are filtered in upper 6-in of sand bed.

pumps, each with a capacity of 630 gallons per minute at 30 feet of water head, were provided. To reduce operator involvement, automation of the backwash sequence was included in the design. The backwash operation could then be controlled by a sequencing timer. This could be initiated manually, by a preset filter head loss trigger, or by a timer.

3. Detention Time - A new detention tank, 15 feet square by 10 feet high with internal baffling, was installed between the mixing chamber and the existing detention tanks. The new tank added 60 minutes to the existing chemical reaction time bringing total detention time to about 80 minutes. The increased detention time ensured the occurrence of almost total oxidation of the iron and manganese. The longer oxidation time also allows the precipitates to form prior to filtration by the activated sand media. This not only prolongs the life of the filter media coating but also minimizes the occurrence of discolored water caused by incomplete manganese reactions.

4. Variation of Manganese in Raw Water - A spectrophotometer was purchased for use in the Plant. The spectrophotometer allows for the timely and accurate determination of the current manganese concentration in the raw water. Proper dosages of potassium permanganate can then be fed into the system to provide for oxidation demand and recharge of the coating on the sand media. Another instrument, a Hungerford and Terry Color Monitor, was purchased to monitor the filter effluent and detect any unreacted manganese which had broken through the filter media with a resultant product water of undesirable quality in the clearwell.

5. Fluctuation of Flow Rates from Water Well Pumps - A flow regulating valve was installed in the raw water influent line to provide a constant inflow rate to the Plant regardless of which well pump is operating.

6. Backwashing Recovery Basin Operation - The backwash water would be collected in the recovery basin. After a quiescent period of a few hours, the supernatant is recycled to the mixing tank. The recycled supernatant volume is estimated to be 11,340 gallons. The precipitated sludge, about 1,260 gallons, is then pumped to the existing sludge recovery tank ("blue tank") located to the south of the treatment Plant. Here, the precipitates are retained within the fine sand bed while filtrates are collected within a perforated plastic pipe. The filtrate then flows to an existing manhole which has been converted to a distribution box. From the distribution box, the filtrate is distributed to a disposal trench system through approximately 100 feet of perforated pipe above gravel-filled trenches. Distribution lines are located two feet below existing grade, but above the historical high ground water table.

   This method of sludge/precipitate disposal should be satisfactory during spring, summer, and early fall months. During winter, however, sludge will be retained in the backwash recovery sump. If solids/precipitates accumulate too quickly, the settled sludge can be pumped to a tank for disposal. If precipitates accumulate as anticipated, no more than 4 percent solids, they will be held in the backwash recovery sump until spring when the ground thaws and the percolation system can be used. Periodically, precipitates which have accumulated in the blue tank will need to be removed and appropriately contained so they can be disposed of at an approved landfill. This disposal method will prevent the arsenic from reentering the ground water.

   The original backwash water recycle pump was rated at 65 gallons per minute at 20 feet of head. The sludge pump was rated at 130 gallons per minute at 20 feet of head.

Both pumps were utilized in the RD modifications though operation of these pumps is now automated with adjustable timers.

7. Inadequate In-Plant Clearwell Storage - A BOR study concluded that an additional 20,000 gallons of clearwell capacity will be required to satisfy the Lidgerwood community's requirements for potable water while maintaining steady-state Plant operation. The study considered the quantity of filtered water used for backwashing procedures and the amount of time needed to backwash during which the Plant cannot treat ground water.

8. Post Chlorination - There are now three post treatment chlorination injection points to ensure the disinfection of treated water. Utilizing gaseous chlorine, chlorine is added at the influent pipeline to clearwells No. 1 and 2 and at the discharge water pumps that feed the elevated water storage tank. The operator controls the rate of chlorine usage (and the resultant chlorine residual) at each injection point by the use of a dedicated gas chlorine flowmeter. A free chlorine residual of 0.5 to 1.0 parts per million is maintained in all treated water.

9. Clearwell Capacity - A BOR study of the operation of the Plant indicated that an additional clearwell capacity of approximately 20,000 gallons would improve and simplify Plant operation. The new clearwell is located under the new addition to the building. The walls of the clearwell were used as piers for the building and a support for the detention tank. This produces a total clearwell capacity of 33,000 gallons at little additional cost over that of the needed building addition to the Plant.

   The location of the new clearwell permits isolation of the backwash feed water from product water storage which provides a simplification in Plant operation. The existing product forwarding pumps were also relocated above the new clearwell.

10. Access Ports - There was no access to the filter underdrains which made these areas impossible to maintain and service. Drains and access ports were added to the filter underdrains so that they could be cleaned out when needed.

11. Building Size - An addition to the original Plant was built to accommodate the new equipment which almost doubled the size of the structure. The addition is structurally and visually similar to the original building for technical as well as aesthetic considerations.

Other possible, although less serious, causes for Plant difficulties were identified. These include:

- The presence of sulfides or organic chelating agents in the raw water and
- A crowded Facility.

In addition to hardware changes, some changes in Plant operations were also investigated. These included:

1. Reactivating recycle of the supernatant liquid from the backwash water sump.
2. Revising the operation cycle of the Plant.
   a. Run the Plant in one continuous stretch during the day.

b. Backwash at the end of the day.

c. Add a short filter-to-waste step to the backwash cycle to avoid putting the first filtrate, which is frequently "off-spec," into the clearwell.

d. Modify the concentrations of chemicals fed to the process.

e. Use greensand in place of the presently used filter medium.

f. Addition of a six-inch layer of anthracite to the top of the filters to improve filter operation and to prolong filter runs.

g. Disposal of sludge generated by the Plant is presently estimated to amount to slightly less than two tons of dry solids per year, consisting largely of iron hydroxide and manganese dioxide.

Startup and Operator training was divided into three areas. First, a refresher course was conducted at a facility which also conducts iron removal. Second, Plant operators were trained on the use of the specialized instruments as described in "4. Variation of Manganese in Raw Water" above. These instruments were also used to assess the quality of the water being delivered to the City of Lidgerwood and to ensure that no off-spec water is sent to the City. Last, operators were provided training based upon the Designers Operating Criteria (DOC). The DOC was developed by the Research and Design Divisions of BOR to reflect the completed modifications and process changes.

The RD was completed and approved in March 1989, only five months after initial involvement by EPA and the BOR. Through a second IAG, BOR was contracted to perform direct procurement and construction oversight of RA activities on behalf of EPA. Total costs for the RD, construction, and training required for the Plant modifications were determined as shown below:

Actual Design Costs:	$196,708.25 (approx. 620 staff days)
Estimated Construction Costs:	
Actual Construction	$389,000.00
BOR Oversight	$172,525.00 (includes an estimated 137 staff days)
City Oversight	$ 15,000.00
Total	$576,525.00
Estimated Project Cost:	$773,233.25

Remedial Action Contractor. The RA contract was awarded to Wanzek Construction on June 5, 1989. The Lidgerwood Project team was now complete and ready to begin the RA phase of the process. The team members included the EPA RPM; a representative of the EPA Drinking Water Branch; the North Dakota State Project Officer; representatives of the City of Lidgerwood which included both the Mayor and the Plant operators; the Project manager for BOR (located at the Billings office) as well as representatives of the Bismarck, Denver, and on-site offices of BOR; CH2M Hill; and Wanzek Construction. Other coordinating members not directly part of the team included the EPA OSC, and internal EPA personnel within Region VIII and headquarters associated with the acquisition of funding for the Project.

DISCUSSION

The construction contract required a total of 20 submittals from the Wanzek Construction. BOR was obligated to respond to each submittal or resubmittal within 15 calendar days of receipt, including the actual day of receipt and the date of response. This short turnaround time led to the adoption of a "fast-track submittal review." BOR would respond to the contractor in writing while BOR's Denver Office completed the review and transmitted their findings to the BOR Project Office by overnight mail. A tabulated system was used to track all the required submittals for the contract.

On-site construction began September 18, 1989. The major components of the construction phase included:

- Site work and earthwork;
- Concrete work;
- Wooden Buildings;
- Detention Tank;
- Mechanical work;
- Electrical work;
- Painting;
- Bottled water supply program; and
- Sequence testing, startup, and Plant operation.

PLANT OUTAGE NOTIFICATION

A Plant outage of 21 days was provided for in the RD and specifications issued for the Project. This Plant outage was required so that the pumps, piping, existing equipment, and new equipment could be connected or reconnected in the appropriate progression. The specifications did require a 14-day written notification of appropriate parties prior to beginning the outage. Unfortunately, this did not specify if receipt of the notification or the date of mailing was to occur 14 days prior to the outage. This became very important since the RPM did not actually receive written notification until four days prior to the outage.

EPA and CH2M Hill had anticipated a 14-day period in which to publish a notification in the Lidgerwood Monitor which would inform the community of the actual dates for the already expected Plant outage and the beginning of a bottled water program. Instead, EPA was forced to use more imaginative methods in which a copy of the prepared notice was "faxed" to BOR in Lidgerwood where copies for hand flyers were prepared. The local Boy Scout Troop (No. 293) then delivered the flyers to Lidgerwood residents on a door-to-door basis.

A related problem concerning late notification of the Plant outage to the BOR, Billings office resulted in late notification to the three suppliers for the bottled water program. Fortunately, the suppliers

were able to obtain adequate quantities of water to meet demand during the initial two weeks of the program and order additional quantities for the remainder of the program.

Another dilemma associated with the Plant outage was that construction began shortly before the Thanksgiving-Christmas-New Year's holiday season. No prohibition against conducting the Plant outage during the actual holidays was included in the specifications. Wanzek Construction originally planned to shutdown the Plant for 21 days starting on November 27, 1989, as part of their construction schedule. However, delays in the manufacture of the detention tank led to delays in Plant shutdown. After the detention tank was finally completed, the contractor informed all parties of their intent to start the shutdown on December 4, 1989. Attempts by EPA and BOR to have the contractor postpone the shutdown until after the holidays proved fruitless. As a result, the Plant was shutdown at 8:00 a.m. on December 4, 1989, and was scheduled to be back on-line by December 21, 1989. Unfortunately, the Plant did not resume operation until December 30, 1989. In addition to incurring stipulated penalties for exceeding the allotted 21-day Plant outage, the contractor's delay in resumption of Plant operations had a predictable impact on the community's perception of "the Government's" ability to conduct construction activities in accordance with our own schedule as publicized in **The Monitor**.

BOTTLED WATER PROGRAM

In addition to the problems related under "Plant Outage Notification," additional issues developed due to the use of three separate supply contractors within Lidgerwood. In an effort to improve public perception of EPA and other governmental agencies, it was determined that three contractors within the local community would be used to distribute the bottled water. Three contractors were used so that residents could go to a business that they usually frequented and, therefore, would not be further inconvenienced by the program. Friction between the BOR and the vendors developed because of differences in the cost per unit reimbursed to the individual vendors. Reimbursement was based upon bids submitted by each vendor and reflected slight variations between the retail outlets.

Other "special concerns" surfaced which had not been previously considered by EPA. These issues particularly influenced the community's regard for EPA since the resolutions directly impacted individual residents.

1. Would the local elementary and high school be eligible for participation in the free bottled water program? Yes, since children, especially those of elementary school age, are more sensitive to even short-term exposure to potential health hazards.

2. Would the local nursing home be eligible for participation in the free bottled water program? While the nursing home could technically be considered a business, it was determined that the nursing home was more realistically a residence to each "customer." As such, each resident of the nursing home was eligible to participate in the program.

3. How could "shut-ins" participate? Would water be delivered to their homes or could neighbors pick up the bottled water for them? It had been determined that the free water would be distributed on the honor system only. While residents were asked to write their name and the number of gallons being taken, the forms were not analyzed to determine if individual residents had taken more than EPA's estimate of three gallons of potable water required by an individual per week. Therefore, the three vendors were instructed to allow neighbors to sign and pickup water for their neighbors. While water would not be delivered to a resident's home, one vendor did provide assistance from the store to residents' vehicles.

4. Would private businesses, such as the Lidgerwood Cafe, be eligible to participate in the program? This was considered but not implemented.

The bottled water program lasted approximately six weeks which included a 26-day Plant outage and a 10-day overlap in the event that other problems arose which would require the Plant to shutdown or made the water unacceptable to Lidgerwood residents. Approximately 14,000 gallons of bottled water were distributed to the Lidgerwood community of which 11,000 were distributed in plastic one-gallon containers. Approximately one week into the program, it was brought to the attention of BOR and EPA that empty water containers were becoming quite numerous. A recycling facility in Moorhead, Minnesota agreed to recycle the containers and the Culligan vendor agreed to serve as a local collection point for the containers. During the three week recycling period, approximately 6,000 containers were collected and transported for recycling.

COMMUNITY RELATIONS ISSUES

As discussed previously, construction updates were to be published in **The Monitor** as a means of easing resident's concerns regarding the Plant. While the first article was more detailed in its description of the Plant operating procedures and difficulties, all the articles followed a format of "Introduction, Background/Progress to Date, Future Activities," and "For More Information" sections. In conjunction with monthly site visits by EPA, informal availability sessions were conducted by the RPM. These availability sessions were publicized within the "Future Activities" section of the articles. EPA and CH2M Hill took great pains to present the articles in a readable manner and to discuss the potential health risks such that residents would not become overly concerned. It was the City's belief, however, that the articles had overstated any health risk and had caused undue terror within the community. In particular, the City felt that the free bottled water program served to further accentuate EPA's stance on health risk and was very much against its implementation.

In dealings with the City, EPA was sensitive to the adversarial roles which had inadvertently developed. It was EPA's determination that a proactive and positive attitude which was favorable to the City would greatly change this adversarial relationship. As the construction progressed and the Plant's operational problems diminished, it was hoped that the City would also come to trust EPA and the other governmental agencies involved with the Project. These hopes were soon shattered as exemplified by the events which occurred in relation to a chemical storage cabinet. The cabinet was replaced twice, despite additional fees for transportation and restocking, at the City's request. The City, however, had formally appointed the Mayor as EPA's only point of contact. Therefore, EPA was criticized for taking direction from another City employee. The City also protested the additional costs involved since the City was providing ten percent of the Project cost.

FUNDING/REIMBURSEMENT OF PROJECT COSTS

The cabinet incident also served as an warning of similar events to come. At a prefinal conference for the Project held on January 30, 1990, the City was informed that their ten percent cost share of Project costs incurred to date would be due on February 15, 1990, in accordance with the SS/PSC. In August, 1990, EPA's finance section alerted the RPM that the reimbursement costs had not yet been paid by the City. After verbally notifying the City of the delinquent payment, a check for only one-third of the overdue reimbursement was submitted to EPA. EPA advised the City and State, which was obligated to provide reimbursement costs in case of default by the City, of the City's legal responsibilities as mutually agreed upon in the SS/PSC and CA, and the possible accrual of interest on the delinquent payment in a written response dated September 14, 1990. A check for the full ten percent of the Project costs incurred as of January 1990 was subsequently submitted by the City on September 25, 1990.

An estimated 137 staff days for oversight by BOR was provided in the second IAG awarded by EPA. It was soon realized that, due to the complexities of the Lidgerwood Project, the presence of an on-site inspector during all phases of construction and Plant startup was crucial to its successful

completion. To date, over 450 staff days by BOR have been required to oversee this Project. In addition, indirect costs incurred by the BOR have escalated from an estimated 35 percent at the beginning of the Project to over 75 percent at completion of the Project.

Besides escalating the total cost of the Project, the additional costs required renegotiation of both the SS/PSC and CA documents already in place with the State and the City. These documents placed a ceiling on the amount of funding which could be expended by EPA for the entire Project. Because the City, and indirectly the State, had agreed to pay ten percent of the Project cost; both the State and City had to agree to any cost increase proposed by EPA. As expected, the renegotiations brought up sensitive issues with the City which have already been discussed.

PROJECT COMPLETION

On January 16, 1991, a final inspection was conducted by the City in conjunction with the Project team. Based on the Plant inspection and results of the approved water quality monitoring program, it was determined that modification of the Plant was 100 percent complete and operating as required. The construction contract was $302,250.00 as awarded. Liquidated damages and change orders resulted in a final contract cost of $318,947.09 which is a 5.52 percent overrun of the original contract value. Current costs for the entire Project including RD, construction, and oversight by BOR and the City are $811,708.25

The Project team's assessment that the Plant was complete formally ended the shakedown and evaluation period and provided for the City to assume all operation and maintenance activities of the expanded Plant. The Completion of the Lidgerwood Project is documented in an RA Report which was approved by EPA on March 21, 1991. Because Lidgerwood is part of the larger Arsenic Trioxide Site, the Lidgerwood Plant will remain on the NPL even though the Project is complete. The entire Site will be eligible for deletion from the NPL once the Wyndmere and Richland rural water treatment projects are also complete. The RA Report for the Wyndmere project was also approved on March 21, 1991, and the Richland project is estimated to be completed by the end of 1992.

CONCLUSIONS

While the Lidgerwood Project has been successfully concluded, the various problems and issues which developed during the conduct of the Project indicate that actions could be taken to prevent their reoccurrence on "the next project." The following suggestions are offered to individuals who may be implementing that next project.

1. Regardless of the anticipated schedule for the project, the specifications would include a clause prohibiting any type of inconvenience to the community, such as the Plant outage, from occurring over major holidays -specifically the Thanksgiving-Christmas-New Year's holiday season.

2. Any required notification clause would specify that receipt of notification is the appropriate action for compliance and would be subject to penalties in excess of standard penalties for other tasks within the Project.

3. With regard to a bottled water program, it is strongly suggested that a single vendor be used to supply all the water so that competitive friction does not develop. Advance consideration by the lead agency of the special concerns discussed in the "Bottled Water Program" section and the availability of recycling options should also be evaluated before considering bottled water as an alternate water supply.

4. Any construction changes which involve additional costs should be approved through the formal concurrence chain only and, thus, avoid any extraneous disputes.

5. The BOR should be encouraged to provide a firm indirect cost percentage, even if it is overestimated, so that EPA can better estimate and request funding in advance of project needs.

6. A better estimate of actual oversight requirements should be provided by BOR, even if it is overestimated. Again, this will enable EPA to better estimate and request funding in advance of project needs.

Despite the "Discussion" which seems to indicate that nothing went right on the Lidgerwood Project, there are many items which were done exceptionally well and which EPA would recommend doing again. First, the development of the **Lidgerwood Design Report** (EPA/BOR, 1989) documented the efforts of EPA and BOR to experimentally examine factors which affect the removal of arsenic from water. This Report has been widely requested by private industry as well as public agencies, and is one of the most informative resources for state-of-the-art arsenic removal. This may become even more important in the near future as EPA continues to consider lowering the MCL for arsenic in drinking water.

Second, oversight by the BOR resulted in a cost overrun of only 5.52 percent for the entire construction contract. This is undoubtedly due to the excellent oversight provided by BOR. In addition, BOR's involvement greatly facilitated the retrofit of the Plant due to their extensive technical and construction expertise. EPA would highly recommend their involvement as a project team member for the next project.

Last, it is observed that EPA's efforts to remedy the adversarial relationship between EPA and the City were mostly unsuccessful. Despite this, it is recommended that these efforts be used for any adversarial relationship encountered on the next project with strict adherence to the formal communication channels. If the relationship is improved, the mutual benefits of improved coordination will more than outweigh the efforts expended.

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IV. GROUNDWATER REMEDIATION

Pitfalls in Hydrogeologic Characterization

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INTRODUCTION

The primary objective of the site characterization program is the collection of information necessary to support remedial action decisions and designs. Information concerning contaminant sources, the severity and extent of contamination, and the hydrogeologic properties of the surface and subsurface materials should be gathered during the hydrogeologic characterization phases. In addition to the acquisition of detailed hydrogeologic and contaminant data, much site specific information concerning other pertinent physical, chemical, and biological processes is required to effectively evaluate contaminant fate and transport processes and for implementation of remediation technologies. The failure to obtain the appropriate characterization data may result in such problems as the implementation of an inappropriate remediation technology, the design of an inefficient remediation system, and the incursion of excessive remediation costs.

The objective of this study is to highlight common omissions in the hydrogeologic phases of site characterization programs. The problems identified in this paper were common to many of the characterizations which were reviewed. The specific focus of this paper is the identification of data gaps which affect ground-water remedial action decisions and designs. The early elimination of these data gaps from site characterization programs leads to more informed decisions concerning remedial alternatives.

BACKGROUND

The site characterization programs conducted under the RCRA and CERCLA authorities at over thirty sites have been reviewed in detail and are compiled for this study. Based on these reviews several common gaps in the identification of contaminant sources and the characterization of hydrogeologic properties were identified. Data from several sites have been used to illustrate these problems and the effects on ground-water remedial decisions. For additional information concerning many of the pertinent issues in hydrogeologic and contaminant transport assessments, the reader is referred to such publications as U.S. Environmental Protection Agency (1989a, 1989b, and 1990).

The use of a phased approach to site characterization offers the opportunity to evaluate data needs in relation to an evolving conceptual model. This was the approach adopted at many of the study sites. The objective of the early characterization phases should be the acquisition of a high quality base of fundamental information from which the initial conceptual model is built or refined. Data gaps should be identified following each phase. The program should then be modified to collect the detailed data required for resolution of these data gaps. While the acquisition of detailed data incurs greater initial costs, the ultimate savings in remediation costs may be substantial through choice of the most appropriate and efficient system.

The level of detail required for an adequate site characterization is dependant upon the subsurface heterogeneity at the site and the remedial technologies under consideration. The hydrogeologic settings of the sites chosen for illustration are predominantly unconsolidated sediments (gravels, sands, silts, and clays) deposited in fluvial and deltaic environments. The hydrogeology at each of these sites exhibits a high degree of heterogeneity and is considered complex. The assessment of fluid flow and contaminant transport in weathered and fractured crystalline rock settings is a highly complex issue and is not addressed in this paper. The reader is referred to such publications as Georgia State University (1988) and Schmelling and Ross (1989) for discussions of special topics and techniques associated with hydrogeologic characterization in fractured rock.

DISCUSSION

The basic objectives of site characterization programs are generally well defined prior to implementation. However, specific data pertinent to remedial decisions are sometimes not obtained. The collection of these data may be neglected due to a lack of awareness of certain pertinent issues. The most significant data gaps identified in review of these characterization programs involved source identification, definition of the contaminant plume, and recognition of the three dimensional aspects of ground-water flow and contaminant transport. Specific discussion and examples concerning the potential effects of these data gaps on remediation design are provided below.

Source Identification

Many characterization programs initially failed to acquire sufficient information to adequately define the sources of ground-water contamination at the site. In determining the extent of ground-water contamination from known or suspected sources, the available data often indicated the existence of additional sources. In some cases the characterization programs

were not modified to locate these sources or to fully define the associated contamination.

Sources for continued ground-water contamination may continue to exist in the subsurface after the obvious surface sources (e.g., surface impoundments, tanks, pipelines, contaminated surface soils, etc.) have been removed. These sources include non-aqueous phase liquids (NAPLs) and contaminants adsorbed to naturally occurring organic material or the surfaces of soil particles (Figure 1). The immiscible phase liquids may exist as mobile fluid masses or as immobile residual contaminant masses which are trapped in pore spaces by capillary forces. The occurrence of contaminants in any of these phases represents the existence of sources for continued contamination of ground water. Many characterization programs did not fully evaluate the existence of these additional contamination sources. Incomplete source characterization may preclude effective source removal. The removal of these contaminant sources is a vital element of remediation efforts.

The choice of appropriate remediation technologies (e.g., ground-water pump-and-treat systems, bioremediation, non-aqueous phase liquid recovery, soil vapor extraction, etc.) may be dictated by the existence of these subsurface sources. Non-aqueous phase liquids trapped in soil pores within the saturated zone are not readily removed using conventional ground-water extraction. The dissolution of these compounds into the ground water is controlled by diffusive liquid-liquid partitioning. Removal of this source using conventional ground-water extraction may require an unacceptable length of time. The evaluation of enhanced remediation technologies at such sites is warranted.

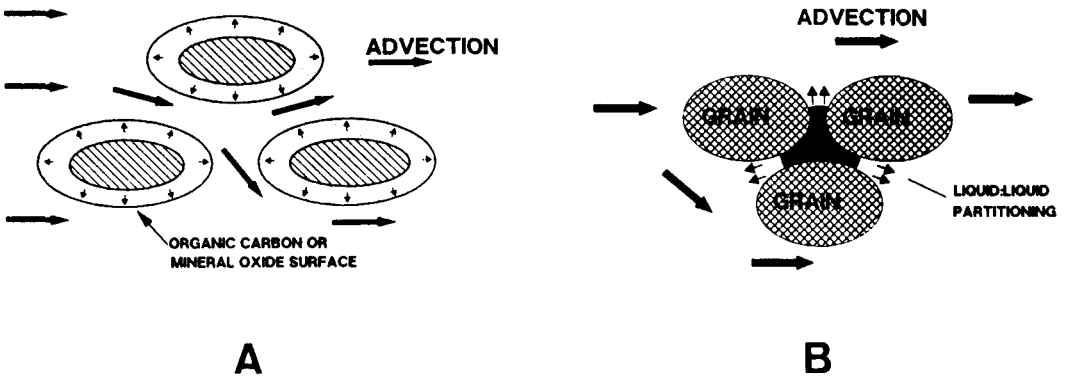

Figure 1. Sources for ground-water contamination in the subsurface. (a) Desorption of contaminants adsorbed to organic carbon or mineral surfaces. (b) Partitioning of non-aqueous phase liquids trapped within pore spaces by capillary forces (from Keely, 1989).

The presence of immobile, adsorbed constituents may also dictate the use of enhanced remedial designs. The rates at which these constituents desorb to the ground water depend on the sorptive properties of the constituent and the properties of the aquifer materials. The number of pore volumes of ground water which must be removed for remediation to be achieved also depends on ground-water flow velocities. Ground-water flow velocities during remediation may be too large to allow the constituents to desorb to equilibrium concentrations. This leads to a decrease in the contaminant removal efficiency of the system. As contaminant concentrations are decreased in the aquifer, the contaminant removal efficiency, as measured by the mass of contaminant per volume of recovered ground water, will also decrease. In such situations the use of enhanced technologies (e.g., pulsed pumping or bioremediation) should also be evaluated to increase the efficiency of the system and reduce the time required for remediation.

Two case histories illustrate the potential effects of incomplete source identification on remedial design. In the first example, hazardous wastes, including various organic liquids, were used and disposed at the site. Based on the specific gravities and solubilities of these fluids, the potential for NAPLs with densities less than water (LNAPLs) and greater than water (DNAPLs) to be present in the subsurface existed.

The characterization program was designed to provide information concerning the existence and extent of dissolved phase contamination. A direct evaluation of the presence or extent of subsurface NAPLs was not initially conducted. In addition, the available data were not examined for possible evidence of NAPLs (e.g., subsurface soil staining, constituent concentrations in percentages of solubility limits, accumulation in wells, etc.). In response to elevated constituent concentrations in ground water, a ground-water extraction system was installed to provide hydraulic containment at the downgradient property boundary.

The extraction wells were designed to fully screen the saturated zone from the water table to the top of a semi-confining unit identified at depths of approximately 50 feet beneath much of the site. Operation of several of these wells resulted in extraction of both contaminated ground water and DNAPLs. Renewed interest in the presence and extent of subsurface DNAPLs led to the detection of significant accumulations of DNAPLs in many wells which were screened above the semi-confining unit.

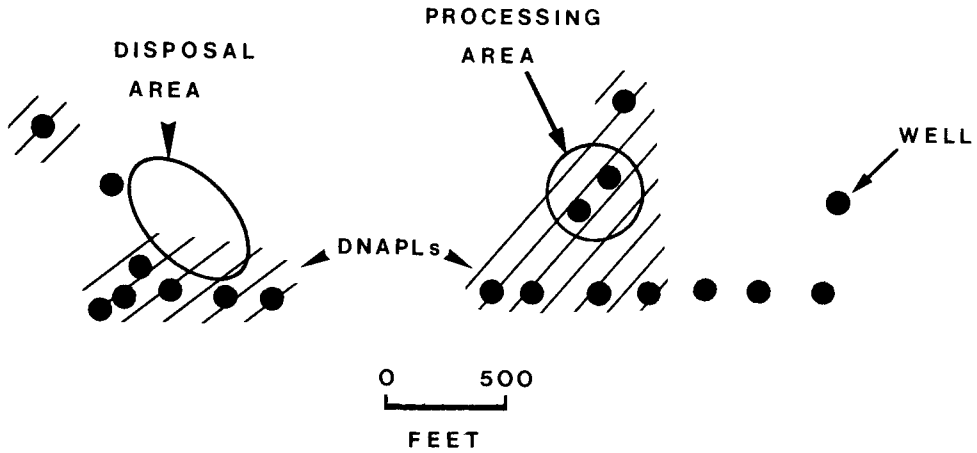

Figure 2. Schematic map with ground-water extraction well locations and the known extent of subsurface DNAPLs, as defined by accumulation in wells, depicted.

The onsite region contaminated with potentially mobile, subsurface DNAPLs was found to be extensive (Figure 2). These fluids represent a major source for ground-water contamination which was not previously recognized. The extent and mobility of the DNAPLs at this site are currently not well defined. Additional studies are required to provide this information and for the design of the most appropriate remediation system.

Another example of complications in remedial design arising from incomplete source characterization is illustrated in Figure 3. Analysis of the hydrogeologic and ground-water quality data from this site indicated that multiple sources of ground-water contamination might be present. However, the characterization program was not modified to provide sufficient data to determine the locations of all sources or the extent and severity of contamination resulting from these sources. As a result, the remediation program proposed for the site (ground-water extraction and treatment) did not effectively address all sources.

An analysis of the proposed system indicated that significant quantities of ground water containing relatively high concentrations of constituents could be drawn into less contaminated portions of the aquifer by the recovery wells. This situation could result in an increase in the concentrations of sorbed constituents within the less contaminated portions of the aquifer and the extraction of greater volumes of ground water to achieve remedial goals. Additional information concerning the extent and severity of contamination was required to design a more efficient remediation system.

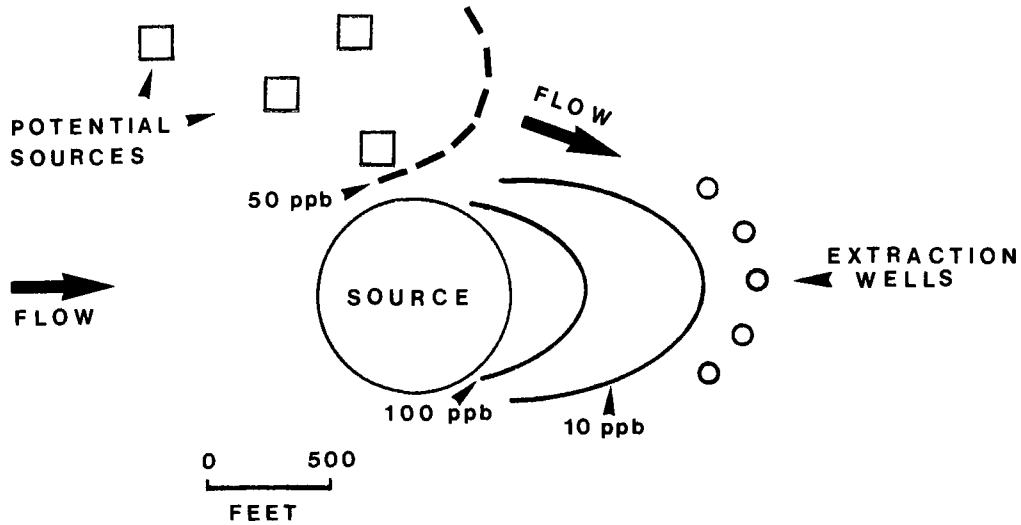

Figure 3. Schematic map showing contaminant distribution in relation to the known and potential sources, the locations of ground-water extraction wells, and the anticipated ground-water flow directions during recovery.

Definition of the Extent of Contamination

Characterization programs sometimes fail to sufficiently delineate the plume of ground-water contamination for remedial purposes. Knowledge concerning the distribution of constituents within the subsurface is required to design a remediation system or to ensure hydraulic containment is maintained within the saturated zone. The horizontal and vertical extent of each constituent should be defined to the specified remedial goals. The optimum spacing of wells and the choice of appropriate screen intervals will principally depend on the mobility of the particular constituents of concern, the composition of the aquifer materials, and the hydrologic properties of the system. A detailed definition of the contaminant plume provides data for calibration of contaminant transport models and allows the design of more efficient remedial systems.

The following case history illustrates one of the potential remedial design complications which can result from insufficient information concerning the contaminant plume. In this situation, ground-water monitoring wells were concentrated within a limited area of the contaminant plume (Figure 4). An additional well was installed within the contaminant plume and immediately upgradient of a potential ground-water discharge point. However, data were not acquired to evaluate the potential for ground-water discharge or recharge.

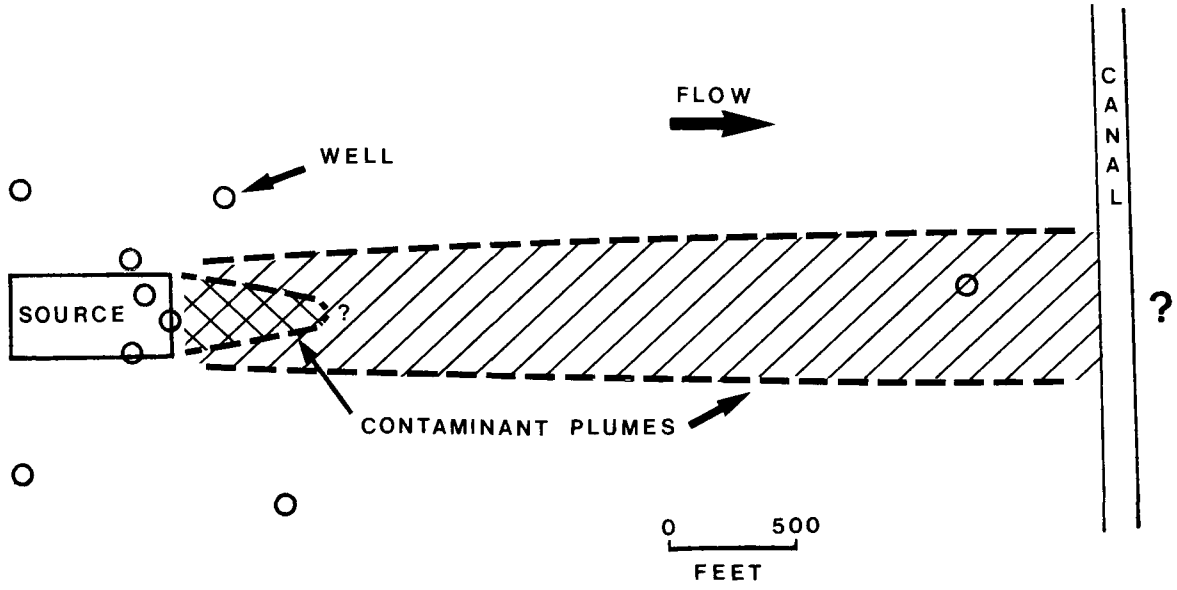

Figure 4. Schematic map showing the contaminant source area, the locations of ground-water monitoring wells, the direction of ground-water flow, and the estimated extent of the contaminant plumes.

Elevated concentrations of both relatively mobile and less mobile constituents were detected in ground-water samples. The available data were not sufficient to accurately define the extent of ground-water contamination due to these constituents. This resulted in a large degree of uncertainty as to the appropriate design or placement of the system components to either remediate or hydraulically contain the contaminated ground water as efficiently as possible. Remedial design using only these data might result in the installation of a system which is highly inefficient and might not achieve the remedial goals within appropriate time periods. It would also be difficult to monitor the effectiveness of the remediation system since the contaminant distribution prior to remediation was not well defined. Additional ground-water monitoring data were required to reduce the uncertainty in remedial design.

Hydrogeologic Description

Frequently, the hydrogeologic system is poorly defined during site characterization. Subsurface heterogeneities result in complex transport pathways. These heterogeneities are difficult to adequately characterize. However, the value of this information in evaluating contaminant transport and remedial designs for the site may be significant. One feature of many characterization programs is the lack of hydrogeologic data collected on a scale consistent with the degree of heterogeneity at the site.

Lithologic samples are often obtained at vertical intervals of several feet during drilling. At these same sites the lithology may be varying within a similar or smaller interval. This may result in the formulation of an inaccurate conceptual model. A preferred approach is to obtain continuous cores or continuous split spoon samples from a representative number of borings during the initial characterization phase. The use of geophysical logging tools also provides additional data for stratigraphic correlations. Based on the interpretation of these data, the sampling interval for additional wells and borings can be established.

Many characterization programs did not obtain sufficient data to define ground-water flow directions and contaminant transport paths within the saturated zone. The most common data gaps involved the lack of either a sufficient number of piezometers screened at appropriate depths or adequate hydrologic testing to define the three dimensional ground-water flow field. These data are valuable in refining the conceptual model for ground-water flow and contaminant transport in support of remedial design. The evaluation of these efforts may lead to an increased understanding of the dominant transport pathways at the site.

A related problem which leads to additional uncertainty in areas with significant vertical hydraulic gradients is the use of wells with long screen intervals to obtain piezometric data. The design considerations of wells installed to monitor ground-water quality and those of piezometers are often quite different. Piezometers should be discretely screened over a relatively small interval within a hydrogeologic unit. The use of spatially clustered piezometers screened within the hydrogeologic units of interest provides more detailed data than can be obtained using wells constructed with long screen intervals. The value of this detailed information depends on the particular hydrologic system and the degree of subsurface heterogeneity at the site.

The acquisition of detailed stratigraphic and hydrologic data should be conducted in the early phases of characterization. The initial characterization phase should include geological and geophysical logging of a sufficient number of borings to provide data for the production of detailed hydrogeologic cross sections. A network of piezometers should be installed, screened at appropriate depths, and monitored to determine ground-water flow directions and any variations related to climatic and anthropomorphic factors. Such factors include seasonal increases in ground-water recharge, variations in the recharge/discharge relationships of ground water to surface water bodies, crop irrigation, and local ground-water usage patterns. Each of these factors should be evaluated in determining ground-water flow directions at a site. A program of hydrologic testing should

also be conducted to provide data for identification of preferential transport paths. The results of these investigations should then be used to refine the conceptual model for the site.

Two examples of the many situations in which detailed hydrogeologic evaluations could be used to refine the conceptual site model and to enhance remedial designs are provided below. The first example is based on a compilation of potential problems identified in review of several hydrogeologic investigations. These problems (Figure 5) include the construction of wells screening multiple hydrogeologic units, the inappropriate use of long well screens, the lack of a sufficient number of wells screened at appropriate depths, and the spacing of borings for lithologic control.

The three wells illustrated in this figure are screened at different depths above, across, and below a potentially extensive clay unit. Based on the intervals and the different units which are screened, the piezometric data are not sufficient to adequately define the ground-water flow directions. The installation of additional wells would be required to determine flow directions in each unit. It should also be noted that well 2 is screened across the interpreted clay layer. In this position it may serve as a conduit for the rapid transmission of contaminants across the clay layer.

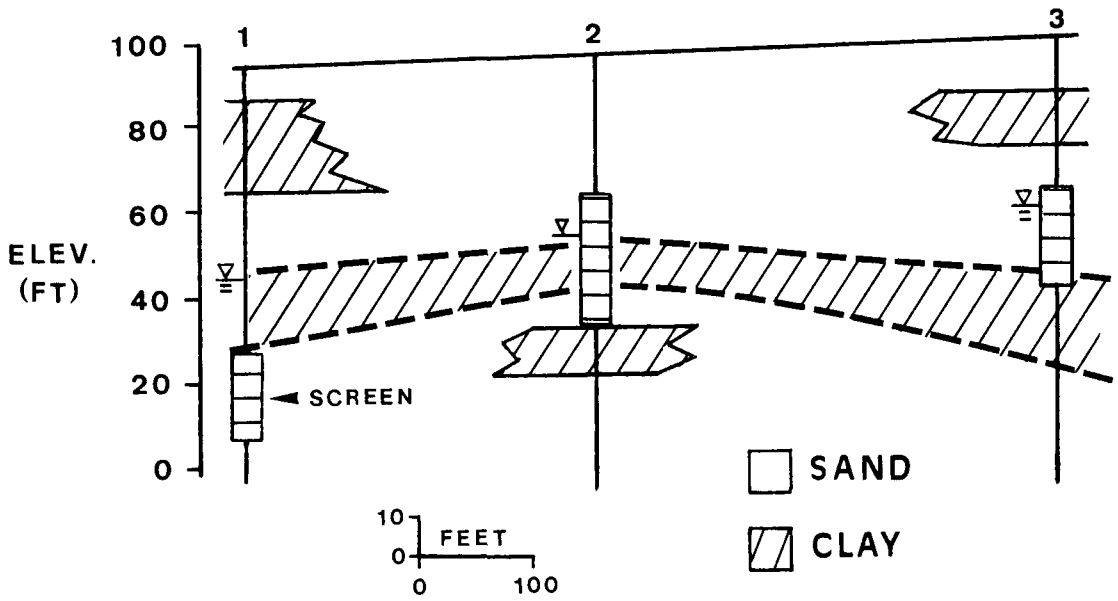

Figure 5. Hydrogeologic cross section showing wells with screened intervals and piezometric data for each well. Elevations are in feet above mean sea level.

The lengths of the well screens in this illustration (20 and 30 feet) may not be appropriate for obtaining either detailed potentiometric data or water quality data. The long screens would not be appropriate for obtaining detailed data in regions where vertical hydraulic or water quality gradients existed. Data concerning vertical gradients may be obtained using spatially clustered wells screened at various depths within discrete units. The use of clustered well installations should be evaluated prior to the installation of wells designed with long screens.

It may also be argued that the spacing of the borings in this illustration is too great to provide sufficient lithologic data for development of the conceptual model. The hydrogeologic interpretation presented in Figure 5 is only one of several possible interpretations which are supported by the limited data. Additional data would be required to reduce the uncertainty concerning interpretation of the clay units as either an extensive layer or as discrete lenses. Additional borings, surface geophysical surveys, and hydraulic testing would provide data which could be useful in discerning the appropriate interpretation.

Each of the practices discussed above will lead to uncertainty in the conceptual model for ground-water flow and contaminant transport at a site. This increased uncertainty translates directly to uncertainty in the appropriate design and placement of an effective remediation or hydraulic containment system. The evaluation and modification of such practices should be conducted throughout the characterization program to ensure that the quality and quantity of data are sufficient to adequately support the remedial design phase.

The final case study illustrates one of the effects of subsurface heterogeneity on remediation efforts. In this example, a ground-water extraction system was installed at a site to provide hydraulic containment and contaminant mass removal. The extraction wells were designed to fully screen the saturated zone from the water table to the top of a semi-confining unit. Two hydrogeologic units with distinct hydraulic properties were identified within the screened interval (Figure 6). The lower unit exhibited a significantly greater hydraulic conductivity than the upper unit. In addition, contaminant concentrations were significantly greater in the upper unit than in the lower unit. As a result of the differences in hydraulic properties, the water recovered by the wells was predominantly from the lower unit.

The use of this design resulted in increased transport of highly contaminated water from the upper unit into the lower unit prior to recovery. This system was inefficient in terms of

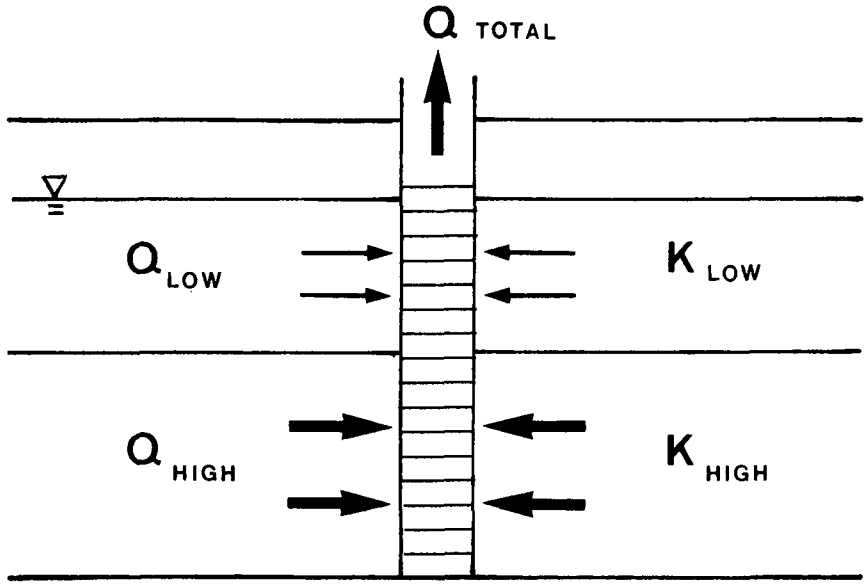

Figure 6. Schematic diagram of ground-water extraction well construction and the hydrogeologic cross section. The relative hydraulic conductivity (K) of each unit and contribution to the total discharge (Q) from each unit in the saturated zone are shown.

achieving the goal of contaminant mass removal compared to a system using extraction wells screened within individual hydrogeologic units. In the present case, larger quantities of less contaminated water must be extracted to recover equal volumes of contaminants. This situation may also lead to an increase in the concentrations of sorbed constituents within the lower unit resulting in increased difficulty in achieving remedial goals. However, the information gained from monitoring the performance of this system has provided much useful data for the design of a more efficient system.

CONCLUSIONS

Several practices identified during this review lead to increased uncertainty in the design of remediation systems. These data gaps often involve the failure to recognize and characterize all significant sources for ground-water contamination at a site. These sources include NAPLs and adsorbed constituents which remain in the subsurface after the surface sources of contamination have been removed. The

potential for the existence of subsurface NAPLs should be thoroughly evaluated during the site characterization program.

Other common data gaps involve a poor definition of the horizontal or vertical extent of ground-water contamination and the failure to evaluate the three dimensional aspects of contaminant transport at the site. These data gaps may result in the design of a remedial or hydraulic containment system which is inefficient or does not meet the required performance standards. An increased awareness of the pertinent site characterization issues and the implementation of a responsive characterization program are necessary to provide the information required for improved remedial designs.

DISCLAIMER

This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's administrative review policies and approved for presentation and/or publication.

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Areawide Implementation of Groundwater Institutional Controls for Superfund Sites

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INTRODUCTION

Institutional controls (ICs) are non-engineering mechanisms used to prevent or reduce human exposure to contaminated areas. ICs are primarily used at hazardous waste sites to supplement engineering actions when there remains a continuing level of risk to human health. The two most frequently invoked ICs are deed restrictions to limit land use and local restrictions on the installation of new groundwater wells where alternative water supplies are provided. This paper provides recent experience gained by EPA-Region III and Chester County Health Department (CCHD) in controlling the use of contaminated groundwater.

The use of ICs to supplement remedial actions is prevalent within EPA's Superfund Program. A recent search through EPA's RODs database revealed that approximately forty-three percent of EPA's Record of Decisions (ROD) include ICs.

Even though they are commonly required, ICs are usually difficult if not impossible to implement as specified in the ROD. This is often caused by lack of planning prior to finalizing the ROD. The resultant requirements for ICs are frequently vague, lacking details concerning the legal authority for the IC and who is responsible for its implementation. From the Federal perspective, implementation of ICs is further complicated due to lack of Federal authority. The authority for ICs is usually derived from either state or local laws. Consequently, as Superfund site managers attempt to implement the ROD, they are often faced with time consuming negotiations with the public and state or local authorities. The net effect is delays in the schedule for implementation of the remedial action.

On the other hand, state and local agencies with the authority to implement beneficial ICs are sometimes hampered due to the lack of data. For example, many local authorities regulate well con- struction and can consequently protect the public from contaminated groundwater. Nevertheless, due to the lack of information flow, they may be unaware of the existence of a Superfund site and may unknowingly be approving new water supplies from the contaminated aquifer. This is partially due to the fact that the Superfund Program addresses contamination on a site specific basis. There is no inherent mechanism to provide local authorities with site related data on an areawide scale.

This report documents a recent initiative by EPA-Region III and CCHD which resulted in the successful implementation of groundwater IC's at nine sites within Chester County, Pennsylvania. This initiative is analyzed from the perspective of both EPA and CCHD. It is provided to assist other hazardous waste site managers and local authorities implement similar procedures where groundwater ICs are a required or beneficial supplement to a remedial action.

BACKGROUND

Chester County is located in southeastern Pennsylvania outside of the city of Philadelphia. Land use in the County has been historically dominated by agriculture. Recently however, there has been a significant increase in single family residences. Due to its predominantly rural composition, approximately sixty percent of the 376,396 residents in the County rely on private residential(individual) wells for their water supply.

Industry utilizes only one percent of the available land in the County. Nevertheless, ground water contamination, especially by the volatile organic compounds(VOCs), associated with industrial solvents, have long been a significant health threat to County residents. As noted in Figure 1, there are nine Superfund sites in Chester County, eight of which have VOC contaminated ground water.

Between 1986 and 1990, RODs were prepared for three of the Superfund sites in the County. Each ROD contained future well installation restrictions as a supplement to alternative water supply actions. In each case the language is very vague. This indicates the authors had little foreknowledge concerning the legal authority for the IC and who was responsible for its implementa- tion. The relevant IC language from the three RODs is:

1. "Administrative controls to prevent the installation of new ground water extraction wells for use within the area affected by ground water contamination should be implemented."

2. "Additional deed restrictions or other institutional devices may be required to reduce the risk of new wells being developed in the area and creating new health risks."

3. "...and to restrict use of ground water by placing limitations on the installation of ground water wells."

CCHD was established in May 1968 under Pennsylvania's "Local Health Administration Law" (PA Act 315). CCHD has actively pursued the sources of the County's groundwater contamination and has identified at least two Superfund sites. One area that is regulated by CCHD is the construction of new individual wells. Their Well Permitting Program requires applicants to test their well water for pH, nitrates, coliform, bacteria, iron, manganese, chloride, color, MBAS(detergents) and odor. Approximately 1,200 new wells are permitted each year.

In October 1989, EPA-Region III presented an overview of the nine Superfund sites within Chester County to representatives of CCHD. After this exchange, the Department became concerned that their Well Permitting Program was approving individual water supplies in areas where the supply may be contaminated from Superfund sites. By using water from this source, the homeowners were possibly placed at risk without their knowledge.

During 1990 CCHD and EPA worked together to incorporate special procedures within CCHD's Well Permitting Program to control the installation of new wells within the Superfund sites' area of contamination. This effort included mapping a reasonable area of concern around each

SUPERFUND SITES IN CHESTER COUNTY, PA.

(LISTED ON THE NATIONAL PRIORITIES LIST)

1. AIW FRANK
   INTERSECTION ROUTE 202
   & ROUTE 30
   EXTON 19341

2. BLOSENSKI LANDFILL
   ROUTE 340
   WAGTONTOWN 19376

3. KIMBERTON SITE
   COLD STREAM & HARES HILL
   ROAD
   KIMBERTON 19442

4. MALVERN TCE SITE
   258 N. PHOENIXVILLE PIKE
   MALVERN 19355

5. PAOLI RAIL YARD
   RR SERVICE SHOP
   PAOLI 19301

6. RECTICON / ALLIED STEEL
   ROUTE 724 S. WELLS ROAD
   PARKERFORD 19457

7. STRASBURG LANDFILL
   STRASBURG ROAD
   NEWLIN TOWNSHIP 19320

8. BARKMAN / WELSH ROAD
   LANDFILL
   WELSH ROAD
   HONEYBROOK 19344

9. WILLIAM DICK LAGOONS
   TELEGRAPH ROAD
   WEST CALN TOWNSHIP 19376

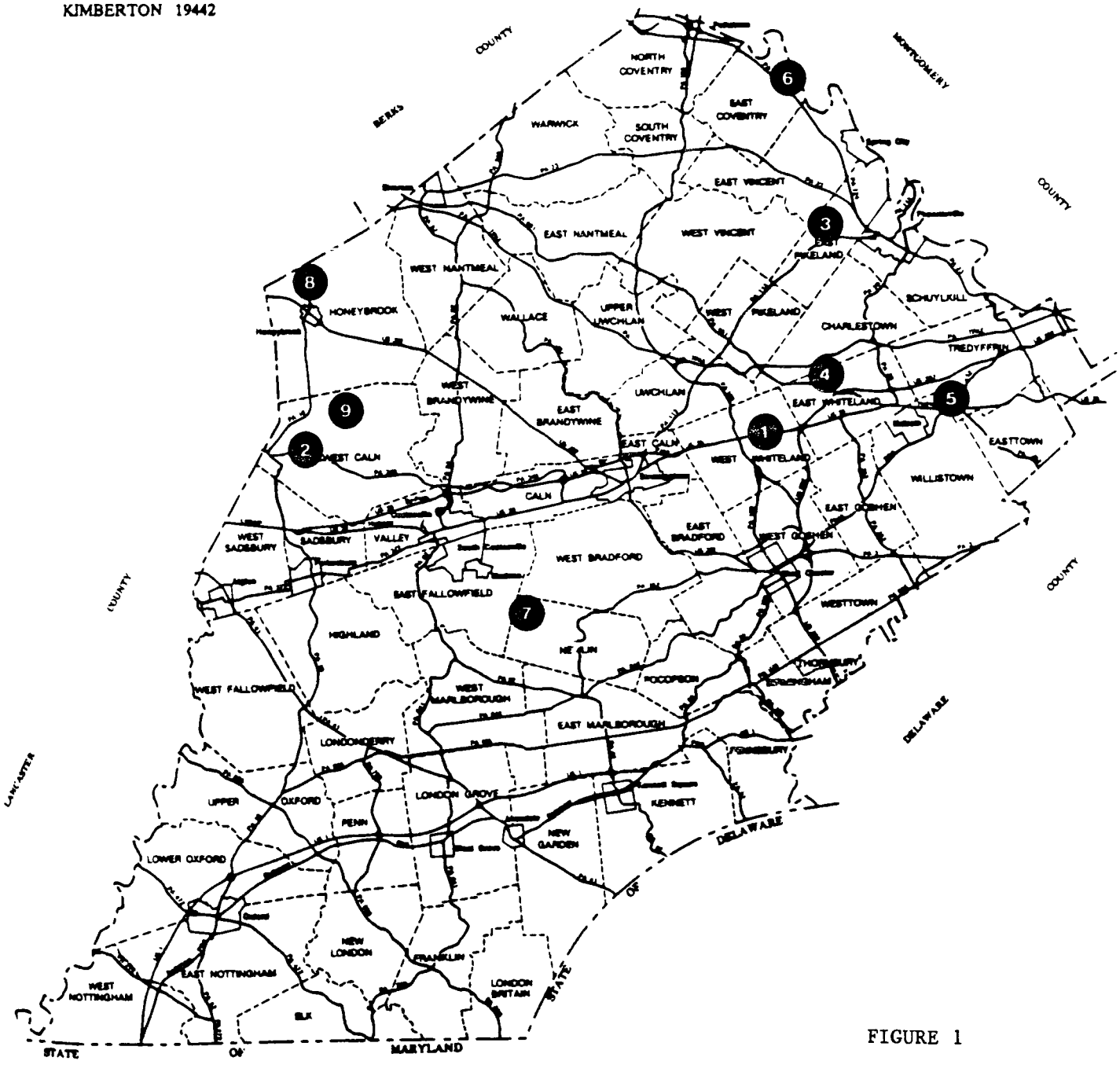

FIGURE 1

rce: U.S. Environmental Protection Agency, 1990.
prepared by: Chester County Planning Commission & Chester County Health Department, 1990.

Superfund site within the County. For those sites that have been fully evaluated, the area of concern was well documented and quite specific. However, in those areas where the site has not been extensively studied, a conservative approach was taken and the area of concern was established to include any area within 1/4 mile of the site. The area of concern can be modified as more data becomes available. In addition, site specific lists were compiled containing the names of the EPA project manager and responsible parties, the contaminants of concern and the recommended analytical methods. Finally, CCHD management provided these maps and lists to their Well Permitting Program staff and revised their permit procedures for wells drilled within the area of concern.

DISCUSSION

The existing CCHD regulations require prior approval of all wells which are proposed to be drilled within the County. The applicant must submit a permit application to the CCHD before proceeding. The application must include the exact location of the proposed well and the location of potential pollution sources (i.e. on-lot sewage systems, fuel tanks, buildings, etc.). The process has now been modified so that upon the Department's receipt of a well application, the well's location is checked against the Superfund site maps to determine if it is within any area of concern. If the well is located within these areas, as condition of the approval to drill, the applicant is required to test the supply for the contaminants associated with the specific Superfund site in addition to the analysis routinely required for all new wells in Chester County. The analytical method used must have a method detection limit lower than the maximum contaminant level (MCL). For VOCs, EPA Method 502 or 524 is recommended. The applicant is also supplied the names of the Potentially Responsible Parties(PRPs) and the EPA Project Manager for the site.

Once the well is drilled, the well driller is responsible for supplying the Department with the driller's log and construction information (depth of casing, type of grout, depth of pump, etc.). The owners must then test the well and obtain a passing analysis prior to receiving approval to use the supply. If the MCLs are exceeded, the well owner must treat the supply for the contaminants of concern. When the treatment unit is installed, a staff member visually verifies the placement of the treatment unit and the supply is retested to assure that the treatment unit is working. As a condition of the approval of the water supply, the applicant is required to analyze the supply yearly for those contaminants that originally exceeded drinking water standards.

By requiring the additional testing around Superfund sites, CCHD has gained some level of confidence that the homeowners are not unknowingly being exposed to unsafe levels of contamination. Also, as all contaminated wells are reported to the EPA Project Manager, EPA may be able to utilize this additional data in their analysis of the site.

CCHD has found that public reaction to the program ranges from extreme gratitude for informing the homeowner of the potential problem, through mere acceptance of the addition testing requirements, to "what do you mean I have to test? My grandfather has been drinking this water for 40 years and he is not dead yet?"

Overall, the project does not consume a large amount of staff time since CCHD staff already reviews every well drilled within the County. The benefits of assuring safe water far outweigh the minute time cost of County personnel. Unfortunately, unless there is a cooperative PRP, homeowner/well applicant must assume the entire cost of analysis and/or treatment. However, the homeowner may legally pursue the PRP to recover the cost if contamination is found and can be directly associated to the site. This has not occurred yet but the potential exists.

CONCLUSIONS

This simple interagency coordination has provided significant environmental benefits for little resources. It has provided support to CCHD in enforcing their well permit program and has enabled EPA to implement the IC requirements of three RODs. In addition, since the ICs have been implemented Countywide, they are controlling some of the risks associated with five other Superfund sites while remedial investigations and feasibility studies continue.

Institutional controls have often had a negative impact on the schedules for the clean-up of hazardous waste sites by consuming the manager's time trying to implement them. The well permit review procedures implemented in Chester County, PA has partially resolved this problem for a number of sites. There is the potential to gain further environmental benefits nationwide by implementing similar procedures wherever a local or state agency has the authority to control the installation of new wells.

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Verifying Design Assumptions During Construction of Groundwater Remediations

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INTRODUCTION

The design of groundwater remediations is filled with uncertainties, often despite good pre-design field investigations. Construction and startup provide the true test of assumptions made during the design process. These phases of the project must be planned properly so as to gather the information necessary to verify the design assumptions. This paper is intended to review basic data which is easily gathered during construction, but all too often is not. This information can be used to improve the operation of the system, speed the resolution of problems or construction claims, or allow for alterations in the design prior to completion of construction. This information is not meant to be a substitute for good pre-design investigations. Two case studies will be discussed which highlight some impacts of construction-generated data.

BACKGROUND

Typical Design Assumptions

Despite often extensive site investigation and data gathering activities which take place during the remedial investigation (RI) and pre-design stages of most groundwater remediation projects, many assumptions must still be made during design. These assumptions usually relate to the conceptual model of the site conditions and the performance characteristics of certain components of the remediation system. Assumptions related to the site model may include stratigraphy between boreholes, aquifer properties, chemical concentrations (both contaminants and natural ions), and seasonal variations in water levels. Assumptions related to the remediation system itself may include yields from extraction wells or trenches and well efficiency. Though many of these parameters are estimated through sampling or testing during the investigation phases of the project, the number of data points available to develop these estimates are usually limited due to time and funding restrictions. Therefore assumptions must be made by the designer regarding the degree to which the available data are representative of the site conditions between measurement points. Additional data generated during construction can be used to refine the site model and verify assumptions regarding performance of the remediation system components.

Case Studies to be Considered

As examples of these typical design assumptions, background information for two sites, the Millcreek Superfund Site, Ohio and a Superfund site in the Southwestern U.S. are presented. In the next section, the verification of these assumptions are discussed.

Millcreek Superfund Site

The site is located in Millcreek Township in Erie County, Pennsylvania, approximately 2 miles southwest of the city of Erie. The 75-acre site was originally a swamp which was filled with foundry sand and slag beginning in 1941. Approximately 4 acres of wetland remain in the southern portion of the site. The north and west portions of the site are covered in deciduous forest. The remainder of the site is covered with low brush and young trees. The site is essentially flat, with the exception of a few mounds of foundry sand up to fifteen feet high. The site is bordered on the north and west by residential areas and a baseball park; and on the east by a combination of residential and commercial/industrial areas. Marshall's Run creek flows along the eastern property boundary. Site features are shown on Figure 1.

The site operated as an unpermitted landfill from 1941 until 1981. Wastes disposed of at the site included non-halogenated solvents, polyester resins, caustics, paint wastes, ink wastes, waste oils, PCB-contaminated solvents, ethylene glycol, grease, and graphite. The site was placed on the National Priorities List in 1984 after preliminary sampling indicated that the soils on site were contaminated with PCB's, polynuclear aromatic hydrocarbons, chlorinated solvents, and heavy metals. The groundwater in the eastern portion of the site and east of Marshall's Run was contaminated with chlorinated solvents.

The site is underlain by glaciolacustrine deposits of fine sand and silt with occasional clayey or gravelly zones. These deposits range in thickness from 15 to 28 feet across the site. They are underlain by very dense fine grained glacial till 2-10 feet thick which directly overlies shale bedrock. Groundwater occurs in the glaciolacustrine deposits and the fill at depths of approximately 2 to 10 feet below the ground surface. Groundwater flow is to the north with some localized lateral discharge to Marshall's Run and the swamp in the southern portion of the site. Contaminants in the groundwater consist primarily of volatile organics, with 1-2 dichloroethene (DCE) being the most frequently detected compound. DCE concentration ranged as high as 1000 ug/l on site and 100 ug/l in offsite downgradient wells. Substantially elevated, but somewhat lower, concentrations of trichloroethene (TCE) and vinyl chloride were also found in both onsite and offsite monitoring wells. The extent of DCE contamination in groundwater is shown on Figure 2.

In 1986 EPA issued a Record of Decision which recommended excavation and consolidation of contaminated soils on-site under a RCRA cap, site grading and placement of a soil cover over the remainder of the site, and pumping and treating of contaminated groundwater. EPA tasked the Army Corps of Engineers with pre-design, design, and construction management to implement these recommendations.

Extensive pre-design investigations were performed. These included drilling and sampling fifty additional soil borings, installing sixteen new monitoring wells, aquifer testing, sediment and surface water sampling, and treatability testing. Extensive computer modeling of groundwater flow and contaminant fate and transport in both the unsaturated and saturated zones was also conducted. Groundwater flow modeling was performed using a two-dimensional model. This model was utilized to simulate various extraction system configurations. Aquifer testing conducted on site indicated that yields from individual wells would be very low across much of the site, which implied that a very large number of wells would be required to capture and remediate the plume. Therefore, it was decided to utilize collection trenches instead of wells. Groundwater modeling indicated that five trenches located along the north and east boundaries of the site would most efficiently capture the plume. The locations of the trenches are shown on Figure 1.

Design assumptions which were made included the following:

1) Extensive characterization of the site had been performed and it was recognized that there was a high degree of aquifer variability across the site. However, for modeling purposes, simplifying assumptions had to be made regarding the distribution of hydraulic conductivities and other aquifer properties.

2) A 72-hour pump test was planned during the pre-design investigations. After drilling of the soil borings and installation of the monitoring wells was completed, a location was selected for the pump test that was considered to be representative of "average" aquifer conditions near the center of the plume. After installation of a 6-inch diameter pumping well, it was discovered that the well would produce less than 1 gpm. It was then decided to pump two monitoring wells with slightly higher yields (6-8 gpm) in order to supply water to perform on-site pilot treatability testing. Slug tests were also performed on all of the monitoring wells. Data collected from the slug tests and pumping during pilot testing were used to determine hydraulic conductivities across the site.

3) The yield from the collection trenches was estimated using the groundwater flow model. Each trench was simulated as a line sink with a fixed groundwater elevation. The operational water level in all five trenches was fixed at the same elevation.

4) The trenches were assumed to be 100% efficient, i.e. groundwater was assumed to be at a uniform elevation along the length of the trench during operation which was the same as the groundwater elevation in the aquifer.

5) Contaminant concentrations in the water produced from each trench were estimated using a solute transport model.

The verification of the design assumptions for the Millcreek site are discussed in a subsequent section.

Superfund Site, Southwestern U.S.

This site is located in a desert basin in a southwestern state. The site is essentially flat with a slight topographic slope to the south-southwest. Currently, the site is used as a municipal airport surrounded by industrial and agricultural concerns. Residential development has also been increasing in the area.

The site was placed on the National Priorities List in 1983 after the discovery of TCE contamination in drinking water wells at the airport and surrounding facilities. Subsequent remedial investigations delineated TCE contamination in two aquifers in alluvial sands and gravels underlying the site. The shallowest plume, with maximum TCE concentrations in excess of 3000 ug/l, extends approximately 7000 feet in a southwesterly direction, generally parallel with the groundwater flow direction. Monitoring well locations and plume configuration is shown on Figure 3. This plume has affected an aquifer not generally used for drinking water. The deeper plume has, however, affected a wider area of the local drinking water aquifer with much lower TCE concentrations.

In 1987, a Record of Decision was signed requiring remediation of the shallow aquifer as an Operable Unit, pending a final site remedy. The selected remedy was for a pump and treat system utilizing air stripping for water treatment and injection wells as a disposal option. The design of the system was

undertaken by a contractor in the summer of 1988. The Corps of Engineers participated technically by providing review comments on the design.

During the early stages of design, the decision was made to allow the design and construction to proceed in two phases; the first of which would address the downgradient half of the shallow plume. Information generated during the first phase would be used to refine the design of the remainder of the system. Groundwater modeling of the performance of the entire system was performed using a three-dimensional contaminant transport model. Design of this first phase was completed in early 1989 and construction was begun in spring of 1989. Start-up of the treatment plant and the phase one wells was conducted in December 1989. The locations of the five extraction and seven injection wells and the treatment plant are shown on Figure 4.

Design assumptions for this effort included the following:

1) The entire site was adequately characterized by monitoring wells with the exception of the downgradient end of the plume; therefore, the design assumed aquifer thickness, depth and character for most of the extraction/injection wells. This is in part the result of a lack of adequate pre-design effort.

2) Although one modest length pump test and one air stripper/injection well test were performed prior to design, these tests were run in the same general vicinity in the upgradient half of the plume. Single-well, short-term pump tests performed in most of the site monitoring wells provided some additional data on hydraulic conductivity distribution, but again wells were widely spaced in the downgradient portion of the plume. Therefore, the design was forced to assume hydraulic conductivities over much of the phase one construction area.

3) The yields for each of the production wells were assumed to be 100 gpm in the computer simulations performed during design.

4) The efficiencies of extraction and injection wells installed in the shallowest aquifer (using the screen slot size, gravel pack, and reverse rotary drilling methods specified in the design) were assumed to be reasonably good (i.e. the wells would produce the required drawdown in the aquifer outside the wells without breaking suction on the pumps).

5) TCE concentrations at the phase one production wells were inferred from the plume mapped from the limited monitoring well data. The variability due to screened interval and pumping rates were not considered. The data were used to project atmospheric TCE loading from the air stripper. In addition, the monitoring wells indicated that natural total dissolved solids (TDS) values varied considerably from under 2000 ppm to over 5000 ppm. Despite this variability, the design incorporated pH control for scaling prevention in the air stripper based on a single assumed value estimated from limited existing data. Other effects of the high TDS were not explicitly considered.

The verification of the design assumptions for this site are discussed in a subsequent section.

DISCUSSION

Various parameters can be gathered during construction to support certain assumptions. These fall into three categories: 1) record keeping - of materials encountered and construction details; 2)

performance testing - well efficiency, production rate, aquifer response; and 3) measurement of existing aquifer conditions.

Good Record Keeping

A great deal of information is routinely generated during construction which can be used to evaluate the validity of design assumptions. However, much of this data is often lost due to inadequate documentation at the time of construction. This can be caused by specifications which do not require construction contractors to provide such documentation, inadequate inspection by the owner's representative, or simply the failure of designers to communicate their information needs to field inspectors.

Construction specifications often do not contain detailed requirements for logging of boreholes drilled for extraction wells, monitoring wells, and piezometers during construction. This is critical to assessing the validity of the conceptual site model developed during the investigation and design phases of the project. The location of components of the remediation system very seldom coincides exactly with the location of borings performed prior to construction, thus requiring the designer to interpolate between existing data points to estimate the subsurface conditions at a particular well. Documentation of the subsurface conditions actually encountered during construction allows the designer to continuously refine the conceptual site model and assess any potential impacts to the design. Construction borings should be logged in detail by a geologist or soils engineer. The field classifications of the materials encountered should be spot-checked by conducting a limited number of laboratory classification tests (grain size analysis, Atterburg limits, etc.) on samples from each boring. If responsibility for logging is placed on the construction contractor, specifications should contain a detailed description of the information to be included on the log and should specify the scale at which the information is to be presented to assure adequate resolution of the details shown. Materials encountered during the excavation of collection trenches should also be documented if the construction method permits. This can be done with an excavation or trench log with complete material descriptions and locations referenced by stationing along the trench. Such documentation of subsurface materials and conditions during construction activities can be used to determine if the actual conditions differ from those assumed in the design in a manner that will adversely affect the performance of the remediation system. Such documentation may also be invaluable in resolving differing site condition claims with minimum disruption to the project.

Good documentation of the as-built configuration of extraction and monitoring wells, piezometers, and groundwater collection trenches is also critical. Specifications should require the construction contractor to prepare detailed installation diagrams and as-built drawings for all of these features. The specifications should give a detailed listing of the information to be included on well installation diagrams. Along with boring logs and performance testing, these records can be utilized to help determine potential causes for differences between the actual performance of the system and design predictions.

Dewatering is often required during construction of groundwater collection trenches or other components of the remedial action which may or may not be directly related to removal of groundwater. Regardless of the reason why the operation is performed, construction dewatering provides an excellent opportunity to observe the aquifer response to hydraulic stress on a scale usually not possible during earlier site investigation phases. However, documentation of dewatering operations is usually not sufficient in detail to allow any meaningful relationship to be developed between the results of those operations and the aquifer properties assumed for design of the groundwater collection system. It will never be practical to conduct construction dewatering in the type of controlled and carefully monitored manner normally associated with a pump test. Promoting such undue restriction on construction operations is not the intent of this discussion. Simple records

of pumping rates and schedules, water levels in excavations and existing monitoring wells or piezometers, and drawings showing the locations of wellpoints, etc. could be easily maintained by either the construction contractor or field inspectors. This information would allow designers to determine the aquifer response to pumping and make simple comparisons to the response which would be predicted using aquifer properties assumed for design.

Maintaining good construction records is the responsibility of designers, field inspectors, and construction contractors. Designers must include provisions in construction specifications to require contractors to provide adequate documentation of conditions encountered and the as-built configuration of wells and trenches. Designers must also communicate effectively with the field inspectors so they know what data they should be collecting, what portions of the construction operation may require special documentation, and why this information is important. Finally, this data must get back to the designers so that faulty design assumptions can be identified in a timely manner. If changes in the design are required as a result of these assumptions, they can be made before construction is completed and the contractor has demobilized. All of these procedures can be implemented at minimal cost to the project.

Performance Testing

The principle design assumptions for most groundwater remediations are the production rate and aquifer response. When the extraction well or collection trench is installed, the production rate using the specified pump is easy to measure and compare to the assumed value. After measurement of a static water level, the production rate should be measured along with the pumping water level in the well or trench. The pumping rate and pumping water level should be recorded at a specific time after pumping began. The ratio of the pumping rate to the drawdown, known as the specific capacity, measured just after construction and development serves as a benchmark against which long term performance is measured. If degradation of the well or trench occurs because of scaling or fouling, the specific capacity will decrease. Future maintenance of the system can be based on the subsequent specific capacity values dropping to a predetermined percentage of the original specific capacity.

The water levels measured in the pumping extraction wells or trenches are often significantly different from the levels predicted based on modeling or analytical equations. This can be due to unexpected aquifer conditions, but can also be a function of the head loss experienced by the flow into the well. This loss is quantified by the well efficiency which is defined as the drawdown in the formation outside the borehole divided by the drawdown measured in the well. Well efficiency can be measured during initial testing of the well by measuring the water level in the well and in a piezometer (small diameter well used for water level measurements) placed just outside of the extraction well borehole. Piezometers do not cost a great deal and they do not need to fully penetrate the aquifer. A piezometer will yield a more accurate measurement of the aquifer response than the extraction well. A significant difference in the drawdown may indicate that the extraction well borehole was damaged during drilling, or the well screen or sand pack was improperly chosen for the flowrate. These problems can then be addressed directly by rehabilitation, redevelopment, or replacement of the well, rather than concluding that the aquifer is incapable of supporting the design yield.

Even with data available from a pump test performed during the remedial investigation or pre-design activities, the design of extraction or collection systems cannot fully account for the natural heterogeneity of the aquifer. Once the extraction well or trench is installed, the opportunity exists for another test of aquifer characteristics. A short term capacity test conducted separately on each extraction well or trench as part of construction can yield valuable additional data. This data can be used to refine the design groundwater model, perhaps even while the drilling contractor is in the field. The need for additional wells/trenches or changed well/trench placement can be added directly. The

location-specific data can also be incorporated into a site model to be used for optimizing long term operation and maintenance of the system. Drawdown can be observed in existing monitoring wells or in monitoring wells installed as part of construction. Locations of observation wells would be chosen as for any pump test. One drawback to consider is the potential need for containment of the contaminated water until the treatment plant is functional.

Finally, the careful documentation of the development of an extraction well, including sand production, turbidity, and volume extracted, can provide data which can assist in evaluating later problems. Sand production records during development can be important in diagnosing pump wear problems during operation. Development records can be evaluated to better design the screen size and gravel pack on later wells; slow development suggests that the gravel pack may be too coarse for the screened interval or that a certain zone should not be included in the screened interval. The amounts of water produced during development can also be used as a guide in planning the initial pumping rates during the capacity tests.

Measurement of Initial Site Conditions:

The measurement of actual groundwater conditions in extraction wells/trenches prior to system start-up can identify significant differences in contamination concentrations, natural ions, and water levels from those projected in design. These differences can affect how the system will be operated and even how the treatment plant would be constructed.

Most significant of the site conditions is often the contaminant concentration. Significant variation from concentrations assumed in design can cause less-than-efficient operation of the treatment plant. The extraction wells are typically constructed to maximize yield, normally screening as much of the aquifer as possible, often much more than the screened length of the monitoring wells. Collection trenches also collect from more of the aquifer than a narrowly screened vertical monitoring well. These conditions often yield more "average" aquifer conditions, perhaps mixing vertically stratified or horizontally varying water quality. Actually testing the contaminant levels in the wells under capacity test conditions (after development) can improve the quality of data available for final treatment design. This assumes that the treatment plant is not completed prior to well/trench completion. Again, if no treatment facility is in place, storage of the pumped water must be available or other provisions for disposal must be made.

In addition to the contaminants of interest, the natural cation and anion concentrations should also be measured to verify the levels assumed in the design for scaling and precipitation prevention measures. Depending on the site conditions observed in the RI and any pre-design and the type of treatment, this could have significant impact on the operation of the plant and any disposal system, including injection wells.

Finally, in areas where seasonal water level fluctuations or outside aquifer stresses may affect the site, the measurement of variations in the water levels in the trenches or wells for a period prior to system start-up may be appropriate. This would be most helpful if the wells/trenches were installed as early as possible in the construction sequence. This information may assist identifying unexpected decreases or increases in well/trenches yield due to changing water levels. It may also assist in identifying variations in contaminant flow direction which may require a different extraction system configuration. This should not be a substitute for good pre-design information on water levels and flow directions, but would quantify the impact on extraction wells themselves or refine the understanding of the effects using the new data.

Verification of Design Assumptions at the Case History Sites

As typical examples of the design/construction assumption verification process, the results of the initiation of construction at the Millcreek and the Southwestern U.S. Superfund sites are discussed. These are not intended to be examples of "how to" or "how not to" but a good review of what is typically encountered and what went right and how things could have been better.

Millcreek Site

Construction at the Millcreek site was initiated in the spring of 1989. Installation of the groundwater collection trenches was a separate contract and was the first activity to be performed. This was to be immediately followed by construction of the water treatment plant under a second contract. Grading and capping of the site would be conducted under a third contract initiated sometime during construction of the treatment plant.

The collection trenches were installed using a trenching machine which excavated the trench and placed the perforated drain pipe and granular backfill in a continuous operation. Trench 4 was the first to be installed. Soon after the initiation of the trenching operation, it became apparent that it would be necessary to dewater the soils in the vicinity of the trench alignment prior to excavation of the trench. The trenching machine was not capable of excavating through the saturated fine-grained soils encountered without becoming jammed and pulling the drain pipe apart in the trench. A line of wellpoints was installed parallel to the trench alignment and pumped to draw the groundwater level down close to the bottom of the trench. The trenching machine then installed the trench in the dewatered soils with much less difficulty. However, concerns were raised about the quantity of water produced by the dewatering operation in relation to the anticipated flow rate for the trench. The contractor reported that pumping rates as high as 150-200 gpm were required to maintain the groundwater level near the bottom of the trench. Computer modeling during design had predicted equilibrium flows from Trench 4 of approximately 12 gpm. Trench 5 was installed next using the same wellpoint dewatering methods. Once again, high dewatering flows were experienced. This pattern continued as the remaining trenches were installed, although the flow rates were not as high as those experienced at Trench 4. This raised the concern that the design treatment plant capacity may be too low to accept the flow rates which might be required to achieve the design groundwater elevations in the trenches during operation. This could result in incomplete capture of the plume.

The construction contractor had begun taking daily water level readings from monitoring wells during installation of the trenches to assess the effects of the dewatering operation. Midway through construction, a flow meter was installed on the dewatering pump and some notations of flow rates were kept. These records were not required by the specifications but the contractor shared the information with the Corps. However, a thorough examination of the data revealed that the amount of detail given was not sufficient for the purpose of using it to determine the validity of design predicted flow rates. While the water level data was fairly detailed, the pumping records consisted of the contractor's personal estimates of the pumping rates and some flow meter readings. However, examination of the flow meter revealed that it was installed so that the pipe was only partially flooded and that continuously fluctuating water levels in the pipe made the meter readings unreliable. There was also no record of when the pumps were turned on and off. This made it impossible to relate the aquifer response seen in the water level data to the pumping from the dewatering operation.

It was decided to run performance tests on trenches 4 and 5 to determine if the aquifer properties assumed for design were valid. Prior to testing, a line of temporary piezometers was installed perpendicular to the trench alignment for use as observation wells during the test. An electric submersible pump was temporarily installed in the trench sump. Each trench was pumped for approximately 90 hours. Pumping was started at a high rate to draw the water level in the trench

sump down to the design operating elevation. The pumping rate was then periodically decreased to maintain the water level in the sump at this level. Water levels in the trench sump, the observation well, and several monitoring wells were periodically measured and recorded during and after pumping. A piezometer had been installed in the granular backfill of each trench during construction and this piezometer was also monitored during each test. The data from the tests was used to recalculate the aquifer hydraulic conductivity for comparison to the values assumed for design. The non-steady state flow rates produced during the tests were also compared to the steady state flow rates predicted by modeling during design.

Trench 4 produced substantially more flow than predicted by modeling during design indicating that it may intercept a more permeable zone not intercepted by nearby wells and therefore not characterized by the aquifer testing performed during site investigations. Water levels in the piezometer in the trench backfill were also substantially higher than the water level in the trench sump. This apparent hydraulic gradient along the length of the trench may be due to a separation or blockage of the drain pipe, interception of a large recharge source by the trench at some point between the sump and the piezometer, or the piezometer may be located outside the trench backfill. The presence of this gradient violates the design assumption of a uniform groundwater elevation along the entire length of the trench.

The results of the performance testing of Trench 5 closely verified the design flow rate and the aquifer hydraulic conductivity. However, whereas the groundwater model had predicted that it would take several months to reach a steady state flow rate in the trench, the performance test indicates that this flow rate will be reached much sooner than anticipated.

Based on the rather mixed results from the performance tests performed on Trenches 4 and 5, performance tests are planned for the remaining three trenches. This will allow the actual steady state flow rate to the treatment plant to be more accurately estimated and potential impacts to the plant design determined. The data from each test will be used to recalculate the hydraulic conductivity of the aquifer at that location for comparison to design values. If these values do not compare well to design values, the groundwater model will be re-calibrated using the new values and any impacts on plume capture evaluated. The operational water levels in some of the trenches may be varied to minimize the system flow while still achieving plume capture. In conjunction with the trench performance tests, groundwater samples will be taken from the trench sumps during pumping to verify the predicted contaminant loading to the treatment plant. A dye tracer test will also be conducted on Trench 4 to verify the integrity of the drain pipe.

In retrospect, the project would have benefitted had performance testing of the completed collection trenches been included in the construction specifications. This would have resulted in more timely acquisition of the data and allowed any changes in the treatment plant design to be implemented with minimal impact to the plant construction. It also may have been more cost-effective to have the construction contractor perform the tests prior to demobilizing from the site, thus reducing setup costs for the tests.

Superfund Site, Southwestern U.S.

Construction was initiated at this site in the spring of 1989. The first activity undertaken was construction of the seven proposed extraction wells. As mentioned above, the phase one well locations addressed the downgradient portion of the plume. The extraction wells locations were chosen without the benefit of pre-design borings at the proposed well sites.

Several of the large diameter wells had been installed when it became apparent that the aquifer conditions were not as anticipated. Well yields were much lower than expected. Boring logs indicated

less sand and gravels than expected; one well failed to encounter productive sand and gravels until the well was advanced into the lower aquifer. When the impact of this became clear, the construction was halted and EPA was petitioned for an extension in schedule to accommodate re-design. Though this is an example of poor site characterization prior to final design, it is also useful to note the well logs and production records generated in construction were used in the re-design phase to refine the site conceptualization.

A second round of well installation was begun in the summer of 1989. Well locations were shifted to the west approximately 900 feet as shown on Figure 4. Pilot borings were drilled at the five new locations prior to well construction and were completed as piezometers. The pilot borings were logged by geologists from the design firm to allow for screen design and to confirm the assumed aquifer stratigraphy.

When it became clear that the aquifer would be productive at the new locations, large diameter extraction wells were installed approximately 50 feet from the pilot borings. These wells were developed and test pumped. Water levels were measured in the pilot boring piezometers during the tests to obtain aquifer parameters. The aquifer parameters determined from the tests will be available for incorporation into models used for the next phase of design, as well as for analyzing impacts of any future system operating change. During the well tests, water levels were also measured in the pumping well. The water levels and pump rates can be used as the benchmark specific capacity for future comparison to determine degradation of capacity.

The production rates were still somewhat less than the 100 gpm per well anticipated in design. The impact of this on the operation of the treatment plant was assessed. The designers concluded that the air stripper could still function to meet regulatory requirements. The production rates achieved were still believed to be capable of establishing a suitable capture zone and this was subsequently proven in system start-up.

Though the pilot boring piezometers were not located immediately adjacent to an extraction well and could not be used to assess well efficiency, they do better represent the actual aquifer response near the extraction wells than the pumping level in the extraction wells themselves. Without the well efficiency information it is not completely clear if the extraction well capacities are significantly hampered by formation damage from drilling or poor well design, though it seems unlikely that the wells are highly inefficient.

The seven injection wells were not tested upon completion as injection wells, though a significant portion of their screened length was above the static water level in unsaturated sand and gravel zones. Pumping tests were conducted and yielded some information in a manner similar to the extraction wells; however, after system start-up it became apparent that several injection wells could not accept adequate water. An additional injection well had to be drilled to maintain adequate capacity. In hindsight, proper testing by injection of water prior to start-up may have been useful. In addition, poor injection well efficiency may be partially to blame for the low capacity, but there was no provision for evaluating injection well efficiency.

Based on observed ion concentrations in monitoring wells, the design incorporated the addition of sulfuric acid prior to air stripping to control pH and to prevent scaling. Actual extraction/injection well-specific cation/anion concentrations were not obtained after well construction. After system start-up, some injection wells began to display significant scaling problems. This problem could have possibly been addressed during the well installation and the treatment plant phase of construction if the appropriate analytical data had been gathered. The pH control system possibly could have then been suitably modified prior to plant completion.

The design allows for individual extraction wells to be sampled. With one exception, the TCE concentration appear to be in reasonable agreement with the values projected from monitoring wells. The well in the most downgradient position, initially yielded water with nearly non-detectable levels of TCE. Unfortunately, this well also produced the largest yield. The production from this well was not significantly reduced for much of the operation to date and now does produce water with low levels of TCE. The TCE plume after almost a year of system operation is shown on Figure 4.

Overall, the first phase of the remedial action is apparently performing satisfactorily. The design of the second phase of the remediation, for the heart of the plume, is about to begin and the information generated by the first phase will greatly assist in the effective design of the second phase. This case study illustrates several lessons learned, most of which should be applied to the upcoming second phase of construction:

1) Scheduling of construction should allow the well production to be determined before piping or treatment plant modification is precluded.

2) As was apparent in the first phase, a pilot boring program provides good information for final well placement and screen design before well construction.

3) The practice of performing pump tests on the wells after installation coupled with water level measurements in nearby pilot boring piezometers provided an excellent opportunity to refine the site model. Similar data from the second phase will allow even better modeling for optimizing system operation.

4) The use of injection wells for treated water disposal will be re-evaluated for the second phase. The injection testing of the recharge system may be preferable to simple pumping tests. Nearby piezometers for measuring well efficiency should be considered to help diagnose any problems.

5) The second phase of construction should continue to allow for obtaining specific well concentrations of ions and TCE. This will be particularly important since the average TCE concentrations should be about five times higher than those encountered in the first phase. The treatment plant will be modified to include offgas treatment and the TCE mass loading rates will be important assumptions to verify in construction.

CONCLUSIONS

This paper urges designers to include adequate requirements for data gathering during construction. There is a need to include the proper provisions for this in the plans and specifications as well as in the instructions to the field. In addition, the construction schedule should consider, to the extent possible, the ability to incorporate information from initial well/trench construction in the final design of other site activities.

Construction specs should include provisions for 1) accurate logging of wells, trenches, and borings; 2) accurate as-built drawings of wells and trenches; 3) measurement of individual well capacities in a way which allows for evaluation of aquifer characteristics and provides an initial specific capacity; 4) documentation of well development and dewatering operations; 5) measurement of well efficiency; 6) sampling of individual extraction wells or trenches for the contaminants of concern if applicable, natural cations and anions; and 7) measurement of variations in static water levels in newly constructed wells or trenches, if likely to be subject to such fluctuations.

The need for and means to obtain all of this information should be explained clearly to the field inspection team. This requires thoughtful preparation of the instructions to the field. Participation of designers with the field inspectors in the initial oversight of certain activities may be particularly helpful.

Finally, if possible, the construction sequence should be structured to allow the full benefit of information gained during the construction. This may be achieved by: 1) the phasing of construction; 2) the drilling of pilot holes or proposed monitoring wells first, 3) installation and sampling of at least some of the wells or trenches prior to initiation of treatment plant construction. Though under many circumstances this may not be feasible, consideration should be given to this possibility in light of the degree of uncertainty inherent in the various design assumptions.

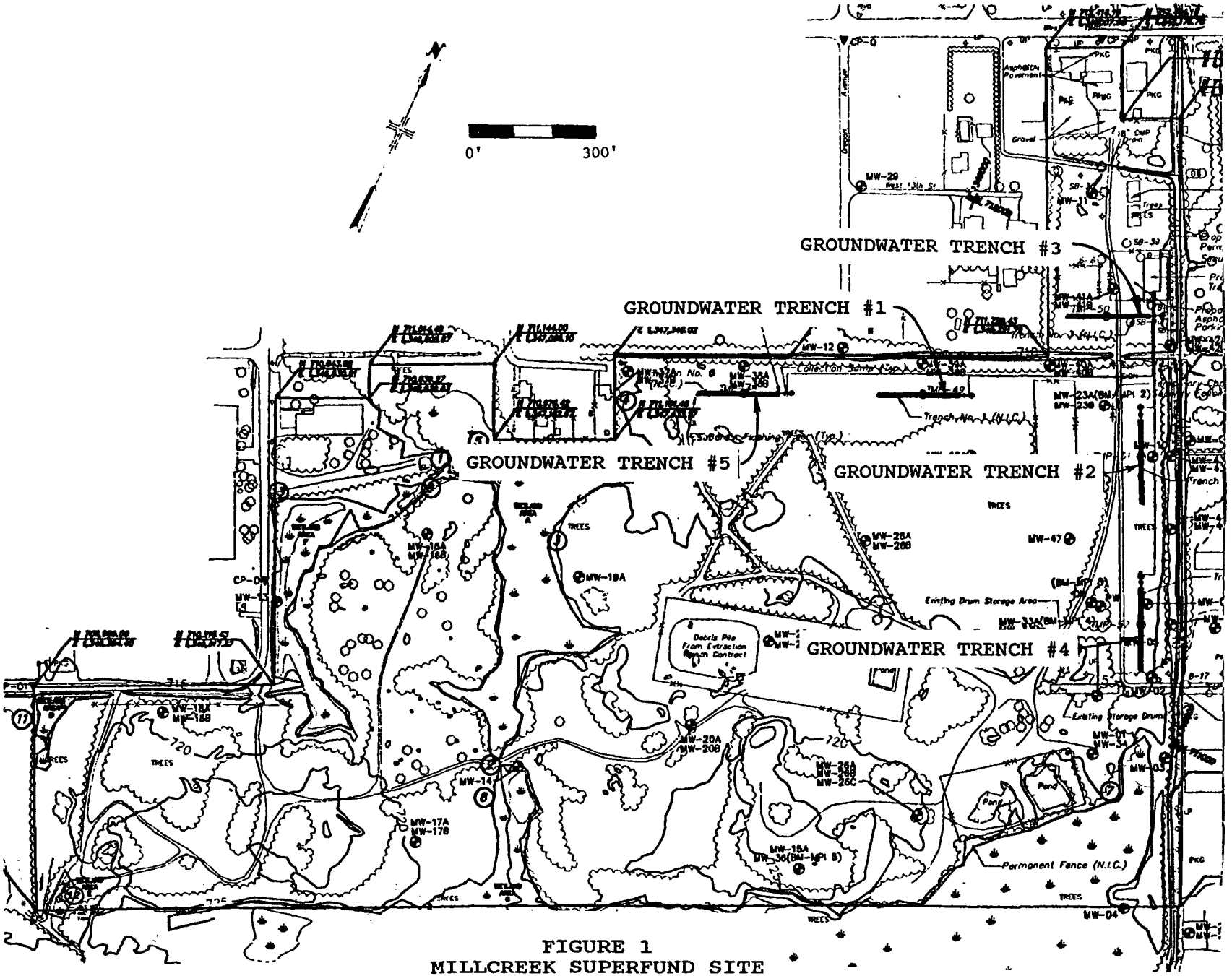


FIGURE 1
MILLCREEK SUPERFUND SITE
SITE PLAN

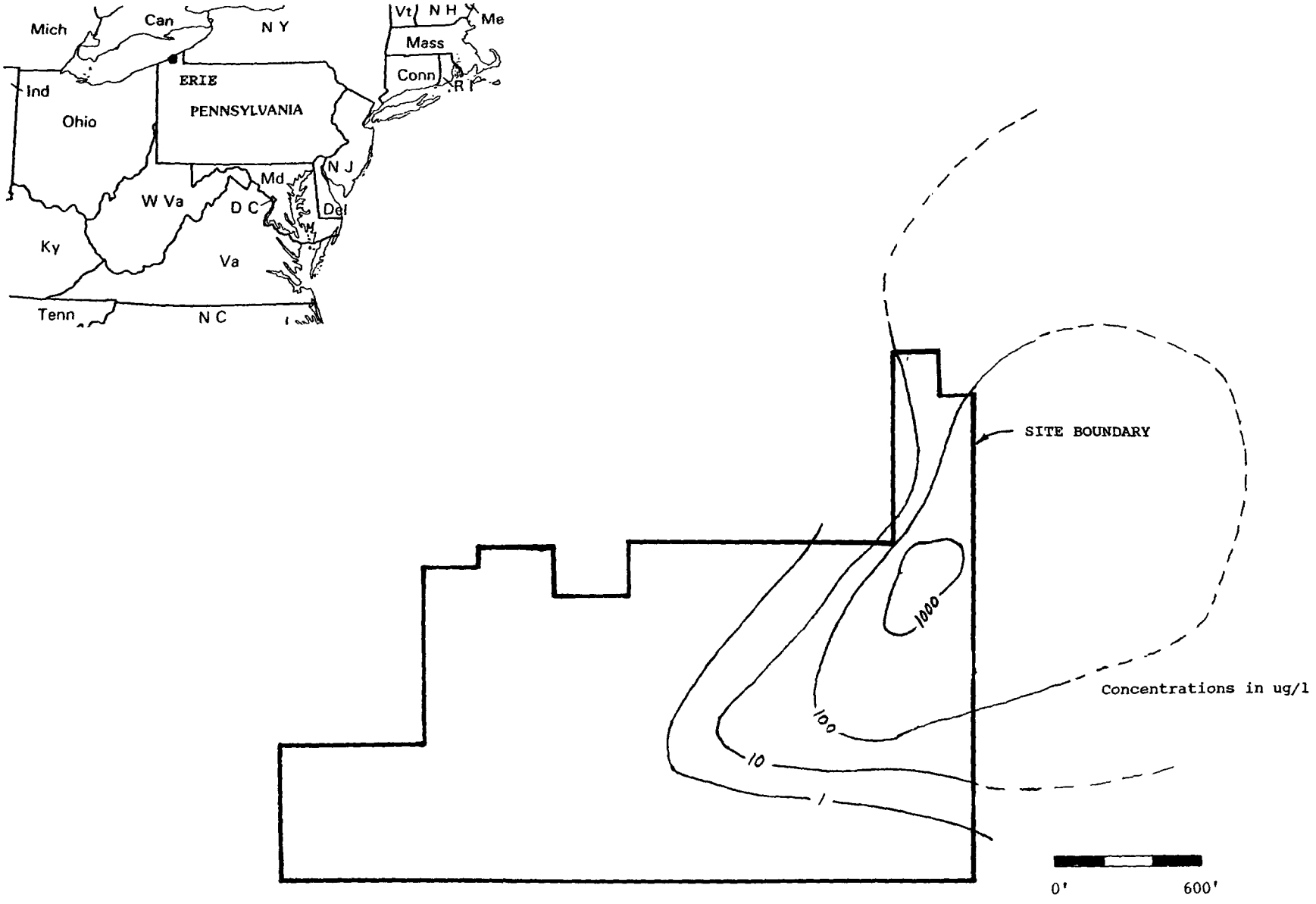
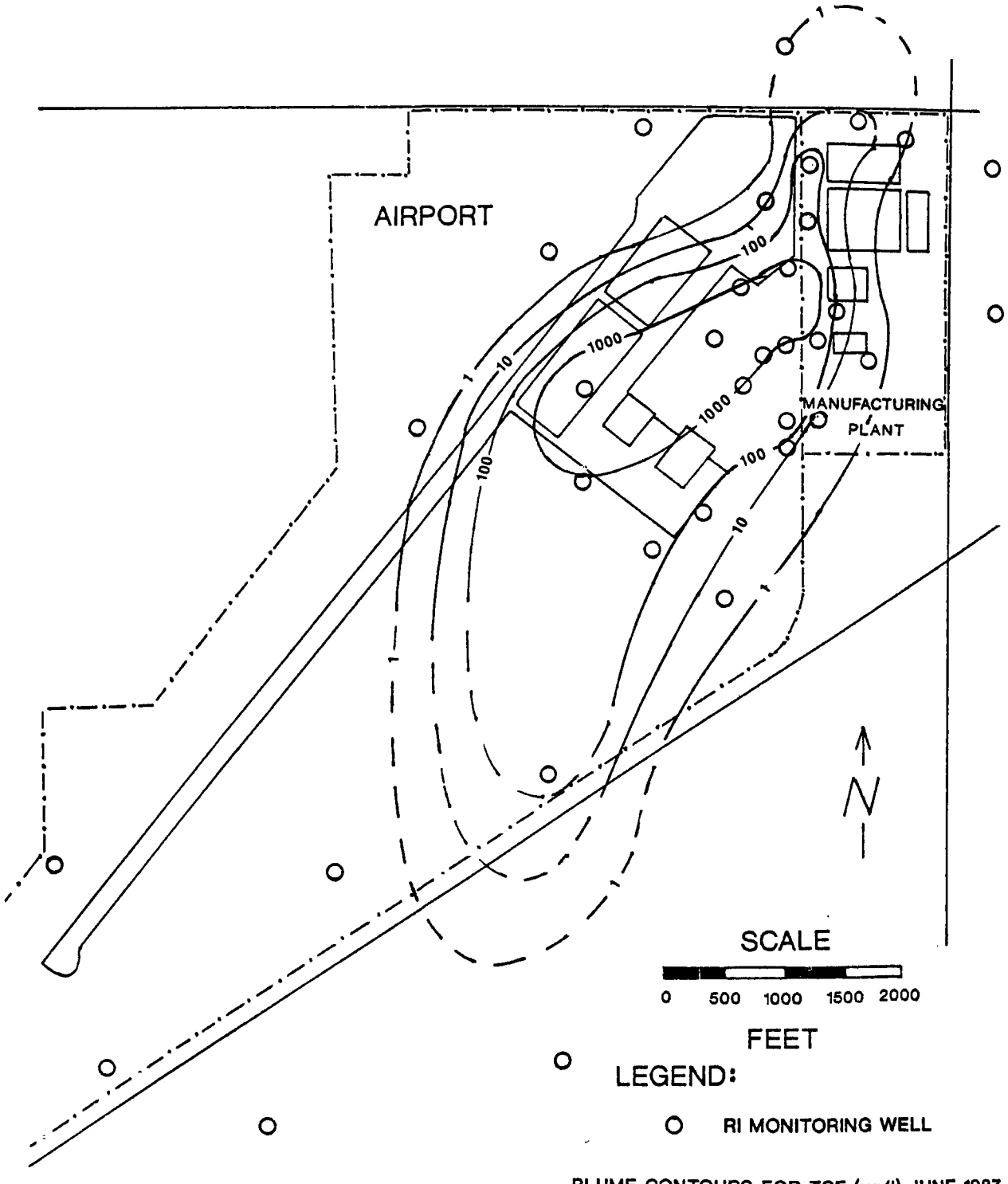
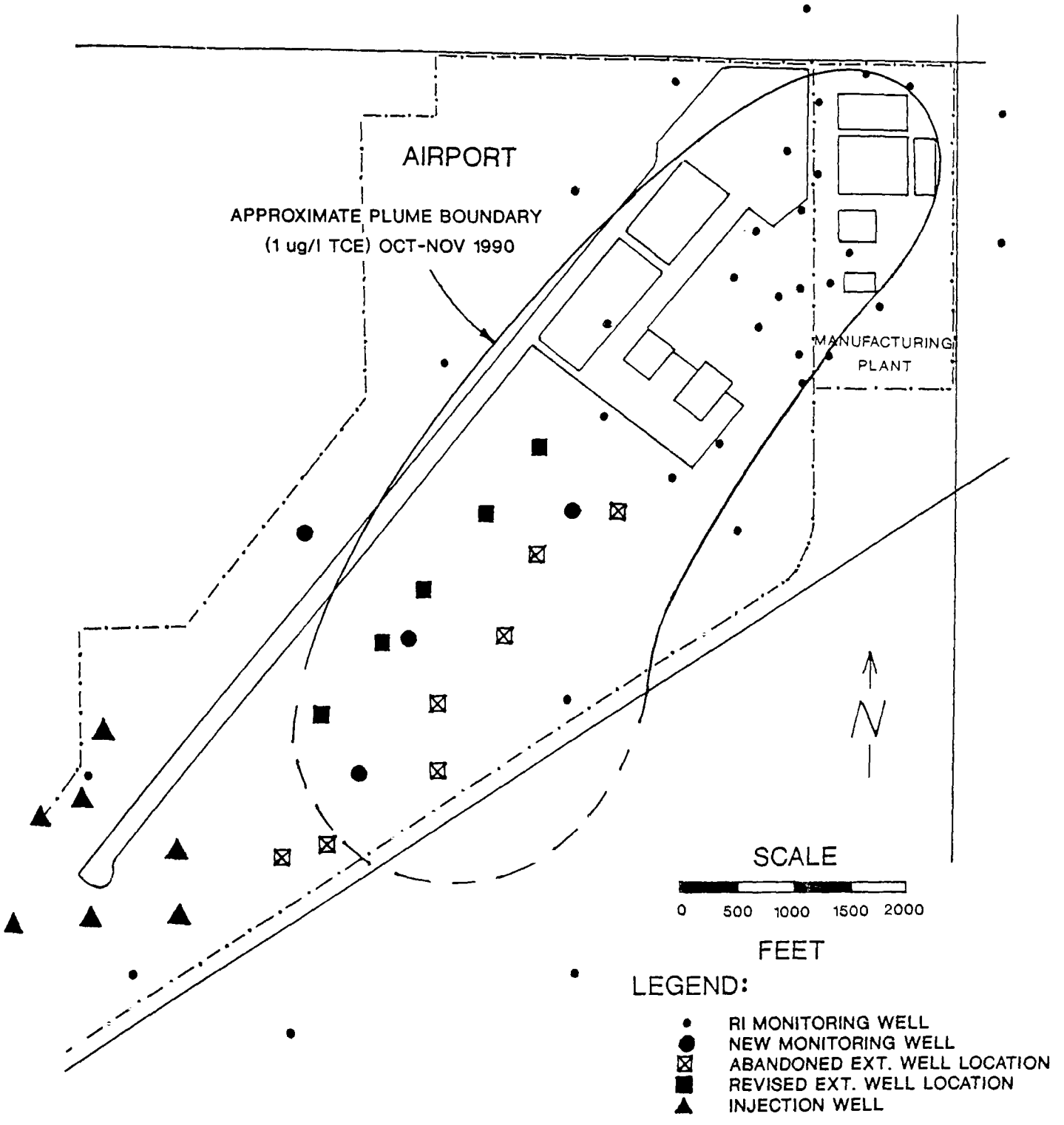


FIGURE 2
MILLCREEK SUPERFUND SITE
DCE CONCENTRATIONS IN GROUNDWATER



SUPERFUND SITE
SOUTHWESTERN U.S.

FIGURE 3
RI PHASE WELL LOCATIONS AND TCE PLUME



SUPERFUND SITE
SOUTHWESTERN U.S.
RA PHASE I WELL LOCATIONS

FIGURE 4

HYDROLOGIC RISK ASPECTS OF HAZARDOUS WASTE SITE REMEDIATIONS

William Doan, Thomas Scott, and Robert Buchholz*

(Author(s)' Address at end of paper)

INTRODUCTION

The identification of hydrologic parameters is an important aspect of hazardous waste sites that is frequently overlooked in Remedial Investigations/Feasibility Studies (RI/FS) and Final Remediation Design.

Many hazardous waste sites are located in flood plains near streams and rivers. The manufacturing/industrial plants that generated the hazardous waste were originally located near streams and rivers because there was a steady water supply and/or convenient discharge point for waste by-products. Unfortunately, because these sites are located in floodplains, they are also susceptible to flooding. If the site is flooded, contaminants may be transported downstream from the site and potentially impact the environment and communities downstream. This is especially critical if the site is flooded during a cleanup where the surface of the site is disturbed, exposing previously buried contaminants.

Another problem encountered in many cleanups is the impacts the final site design may have on the surrounding area from a hydrologic standpoint. The impacts a final design may have on the surrounding watershed must be identified, especially in urban areas. Changing the site characteristics can increase runoff to the surrounding area and induce flooding. If drainage channels are not designed properly, the result can be a long term maintenance problem. Many problems encountered at completed cleanup sites could have been avoided if a hydrologic/hydraulic analysis had been completed during the RI/FS phase. This is a small up front cost that could avoid long term maintenance headaches and costly redesign. It could also eliminate or reduce potential litigation from local entities should a cleanup design result in transport of contaminants downstream.

This paper deals with various ways traditional hydrologic engineering methods may be used to provide both a better overall understanding of the site and a better engineering solution to cleaning up the site.

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FEDERAL REGULATIONS

Several Federal regulations exist which require the characterization of flooding potential at hazardous waste sites. The primary purpose of the regulations are to minimize adverse effects to man and the environment. The intent of the regulations is to insure that one of the primary goals of remediation of hazardous waste sites is to limit the migration of hazardous waste below a specified risk level. Appendix 1 describes pertinent regulations in further detail.

REMEDIAL INVESTIGATIONS AND FEASIBILITY STUDIES

EPA's Handbook "Guidance for Conducting Remedial Investigations and Feasibilities Studies Under CERCLA" lists the types of surface water information required to provide an adequate site characterization. The list of surface water information required includes:

Stream flows
Stream widths
Stream depths
Channel elevations
Overland flow
Soil erosion rates
Sediment transport
Surface water impoundment dimensions
Flooding tendencies
Stream volumes
Transport times
Dilution potential
Potential spread of contamination
Channel flow patterns
Flow restricting structures

With most RI/FS reports few, if any, of the parameters listed above are identified in detail. When the parameters are defined, they are usually defined for normal flow conditions only. Normal flow conditions are for the most part, innocuous in terms of contaminant transport potential. High flows are much more critical because they can exceed the capacity of the main channel and flow into overbank areas. The flow depths and velocities in the overbank may be high, thereby increasing the erosion potential of the site and consequently, the contamination potential.

Realistically, flooding depths, velocities, and areal extent cannot be physically measured during a typical RI/FS

site visit. With a minimum amount of effort, though, the critical surface water parameters can be determined through routine methods involving statistical analysis and mathematical modelling.

Many established techniques and methodologies used in the analyses of traditional water resources projects can be used directly in analyzing and designing cleanups of hazardous waste sites. While there are exceptions to the rule, most RI/FSs do not use these methodologies in the RI/FS and design processes. By using standard methods of hydrologic engineering, the characterization of certain hazardous waste sites and the design of remediation efforts would be greatly enhanced and the end product would be a better engineering solution to the problem.

HYDROLOGICAL INVESTIGATIONS FOR RI/FS

Listed below are several steps in a typical RI/FS process, and methods of traditional hydrologic analysis that would improve the overall analysis.

I. Physical Characteristics of the Site -

The site physical characteristics are intended to define potential transport pathways and receptor populations and to provide sufficient engineering data for development and screening of remedial action alternatives. In terms of surface water hydrology, EPA's Handbook "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" states that the transport mechanism is primarily controlled by flow. The mechanism would probably not be chronic or a continuous process over time. This transportation mechanism, though, would most likely be episodic in nature and occur at periods of high flows when the flow velocities are large enough to cause significant erosion problems.

Flood Flows- Flood flow frequency analysis is based on the observation that the peak annual flows in creeks and rivers can vary greatly from year to year. There are established hydrologic methods for estimating flood events and are summarized below along with an example.

Statistical Methods- If the site is next to a major river or creek, there is a possibility that a stream gage with a long term period of record may be located nearby. The United States Geological Service maintains stream gages throughout the U.S. In 1981, the U.S. Water Resource Council, comprised of members of several Federal Agencies, such as U.S. Army Corps of Engineers, EPA, USGS, etc. devel-

oped consistent techniques for flood flow frequency analysis. These techniques are published in Bulletin 17B "Guidelines for Determining Flood Flow Frequency". The guidelines were established for all Federal water and related land projects.

Bulletin 17B, essentially, assigns a probability distribution (log-Pearson Type III) to the series of annual peak flows for a given stream gage. The log-Pearson distribution requires three statistical parameters to define the flood flow probability distribution; the mean of the annual peak flows, the standard deviation of the annual flows, and the skew coefficient that displays the frequency symmetry. Bulletin 17B also lists various techniques to refine the frequency analysis. These techniques include; expected probability corrections to correct for natural bias in the streamflow data, methodology for weighting the station skew with skews of nearby gaged stream locations, adjustment for historical flows, expected probability adjustments, establishing confidence limits, etc. The end engineering product of the analysis will be an estimate of the flood flow frequency relationship of the stream. An example use of statistical methods in hydrologic engineering is demonstrated as follows for the physical characterization of a 14 acre hazardous waste site in Pennsylvania.

The site in this example is immediately adjacent to a river that has a drainage area of 255 square miles and is located a few hundred feet downstream of a USGS gaging station. A sequential plot of the annual peak flows which demonstrates the variance in flows is shown on Figure 1. A log-Pearson flood flow frequency analysis of the site was performed according to Bulletin 17B guidelines and the resulting discharge-frequency curve is shown in Figure 2 in terms of percent chance exceedence. The 20 percent chance exceedence means that in any given year, there is a 20 percent chance that the annual peak discharge will be 19,000 cfs or larger. Another way of stating this would be a flow of 19,000 cfs or larger would occur once every five years, or, on the average, the five year frequency flood would be 19,000 cfs. A river stage-discharge rating curve at the site developed from past flood events showed that a flow of 19,000 cfs would result in a flood elevation that would begin to encroach on the active areas of the site.

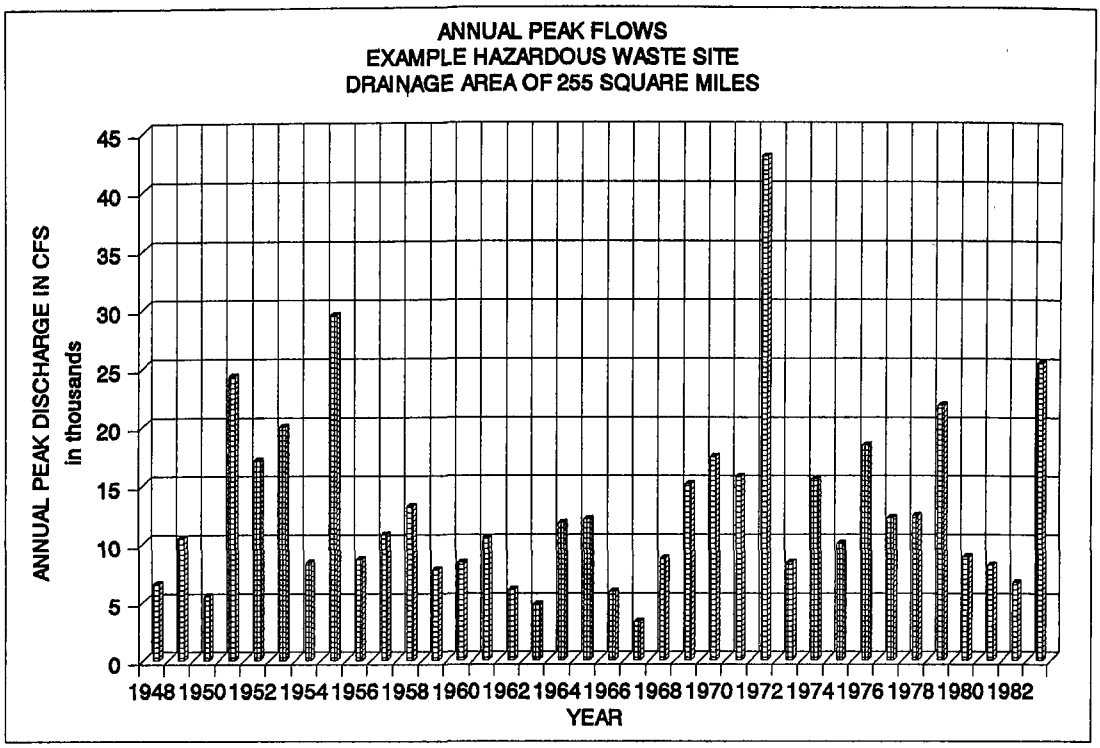

FIGURE 1
ANNUAL PEAK FLOWS

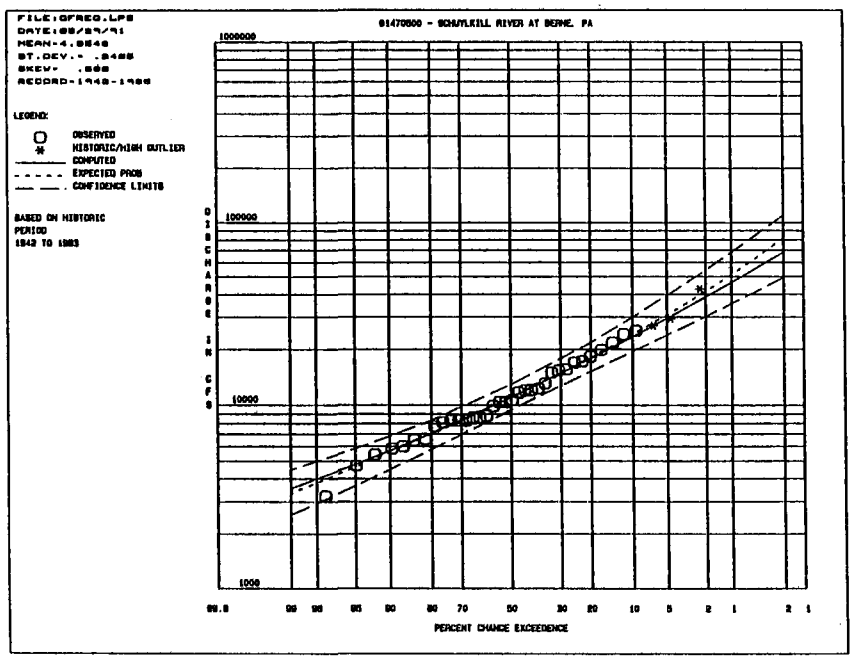

FIGURE 2
FLOOD FLOW FREQUENCY CURVE

Flood Stages - The determination of flood stages are necessary to define the depth of flooding and the lateral extent of the floodplain at and adjacent to the site. As a minimum, the 100-year floodplain should be delineated in accordance with Federal Emergency Management Agency (FEMA) guidelines. However, smaller events such as the 2-year flood could also have negative impacts to the site. It is important to evaluate the impacts of flooding before, during, and after construction.

A preliminary investigation of the historical flooding in the area should be conducted. This can be accomplished by interviewing local government officials and residents of the area and obtaining flood information from newspaper accounts. If the site is located in an urban area or along a well defined channel, there is a good possibility that a flood insurance study has been completed. A brief explanation of the National Flood Insurance Program (NFIP) follows:

> The NFIP was established by the National Flood Insurance Act of 1968 and further defined by the Flood Disaster Protection Act of 1973. The 1968 Act provided for the availability of flood insurance within communities that were willing to adopt floodplain management programs to mitigate future flood losses. The act also required the identification of all flood plain areas within the United States and the establishment of flood-risk zones within those areas. The results of these studies are set forth in a final Flood Insurance Study (FIS) report, which contains a written section, profiles, figures, and tables. In addition, an essential product of the study is the Flood Insurance Rate Map (FIRM) and the Flood Boundary and Floodway Map (FBFM), which is distributed to the community, Federal and State agencies, and others. The FIRM provides 100-year flood elevations and the 100- and 500-year flood outlines. The FIRM also depicts areas determined to be within the regulatory floodway, 100- and 500-year flood outlines

It is important to determine if the waste site is within the regulated floodway or within the 100-year floodplain. A floodway is defined as the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height. In most cases, construction is not allowed within a designated floodway without special permits or permission. Any capping or raising of the natural ground surface within the floodway may not be permitted. A depiction of a channel floodplain and floodway as defined by FEMA is

shown on Figure 3.

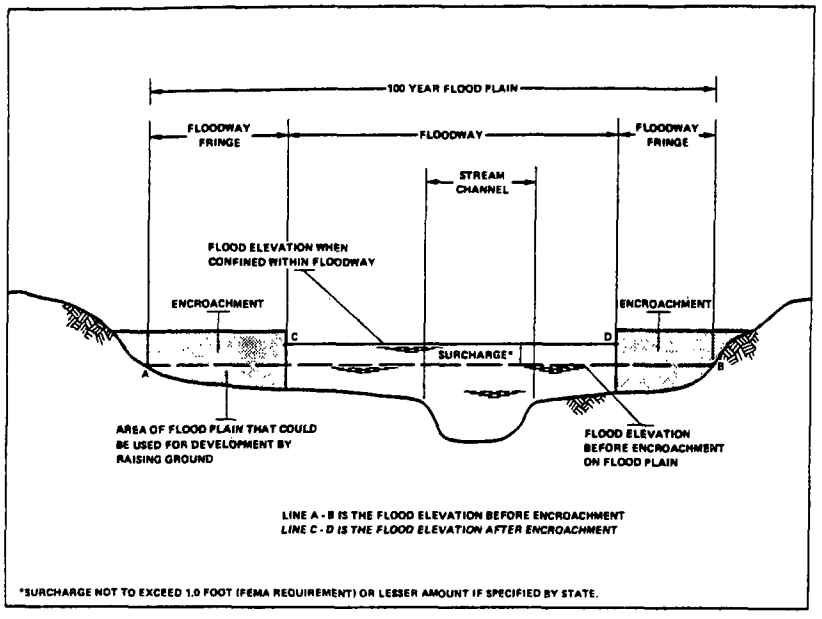

FIGURE 3*
FLOODPLAIN AND FLOODWAY DEPICTION

*From FEMA's "Guidelines and Specifications for Study Contractors"

Once the preliminary investigation is completed, it may be necessary to develop a hydraulic model such as the HEC-2 Water Surface Profile model to determine the flood stages in the area. Variables needed to configure the model include roughness coefficients, cross section geometry, and a range of steady state discharges corresponding to various frequencies of occurrence. A hydraulic model of the stream can provide information on the depths of flooding for various discharges, velocities in both the channel and overbanks, and the extent of flooding. The hydraulic model can also be used to evaluate changed site conditions. An example would be a landfill located within the floodplain but outside of the floodway. The final design may be to cap the landfill with a six foot layer of soil. The existing topography of the site would be changed potentially raising flood stages because of the reduced conveyance capacity. Velocities could also be increased. This could impact on the design of the cap since the velocities may cause scouring of the cap material and floodwaters could encroach on the new cap. Modeling of the changed site conditions with a model like HEC-2 would aid in the identification of these impacts and whether they warrant further study.

II. Contaminant Fate and Transport -

Contaminant fate and transport can frequently be estimated on the basis of the site's physical characteristics. In cases where surface water is the transport mechanism, there are a broad range of hydrologic modelling methods that can be used to define contaminant fate and transport.

An important aspect of surface water contaminant transport is that in many instances it is not a continuous process over time, but occurs at irregular periods during infrequent hydrologic events. An example of this would be a temporary collection lagoon that breaches during a large flood event. Another example would be a several acre hazardous waste site next to a river that receives overbank flooding on a periodic basis. A thorough understanding of the basic nature of surface water hydrology, hydraulics, and associated risks is essential before any attempt is made to analyze contaminant fate and transport via surface water pathways.

Contaminants have three potential modes of transport in surface water flow: sorption in the sediment that flows in the surface water, transport as suspended solids, and transport as a solute (dissolved). The transport of dissolved contaminants can be directly tracked by characterizing the surface water flow nature of the particular site. Sediment and suspended solids transport can be analyzed by traditional sediment analyses techniques as various sediment transport equations, 1-dimensional, or 2-dimensional computer simulation models.

For sites where the contamination can be considered dissolved, the sites can be analyzed by the following established hydrologic modelling techniques:

<u>Rainfall/Runoff Simulation</u>- Rainfall/runoff models are important in analyzing surface runoff because rainfall records are usually more readily available than direct surface water records. A computer simulation model which can transform the rainfall process into runoff process is an important tool in analyzing a watershed. One method of rainfall runoff model is the type that directly uses the equations of physics and basin geometry to simulate the actual physical watershed processes such as soil infiltration, overland flow, channel flow, etc. An example of a 5 square mile drainage basin is shown below:

The Hydrologic Engineering Center's HEC-1 Flood Hydrograph Package was used to develop a rainfall/runoff model

for the drainage basin. The basin contained several hazardous waste sites throughout the basin. The basin also has several dams and reservoirs located throughout the basin. The problem exists of trying to track the contaminants as they pass through the watershed and eventually accumulate in the reservoirs. A physically based model was originally set up in HEC-1 to determine existing conditions design flows, but could also be adapted to model past flood events as a means to determine contaminant fate and transport. The basin was broken down into 122 subbasins as shown in Figure 4. A historical storm occurring May 5 - May 6, 1973 was used to simulate the actual rainfall/runoff process of the site for a 24-hour period. The rainfall distribution of the 24-hour period was derived from a nearby raingage station. The 2.5 inch rainfall was applied to the model to produce the inflow hydrograph shown on Figure 5 for a small reservoir located in subbasin 431. The model simulated the peak inflow into the reservoir, the corresponding pool raise of the reservoir, and outflow from the reservoir. Methods employing this type of analysis help duplicate and quantify contaminant fate and transport mechanism for surface water contamination where no direct streamflow records were kept.

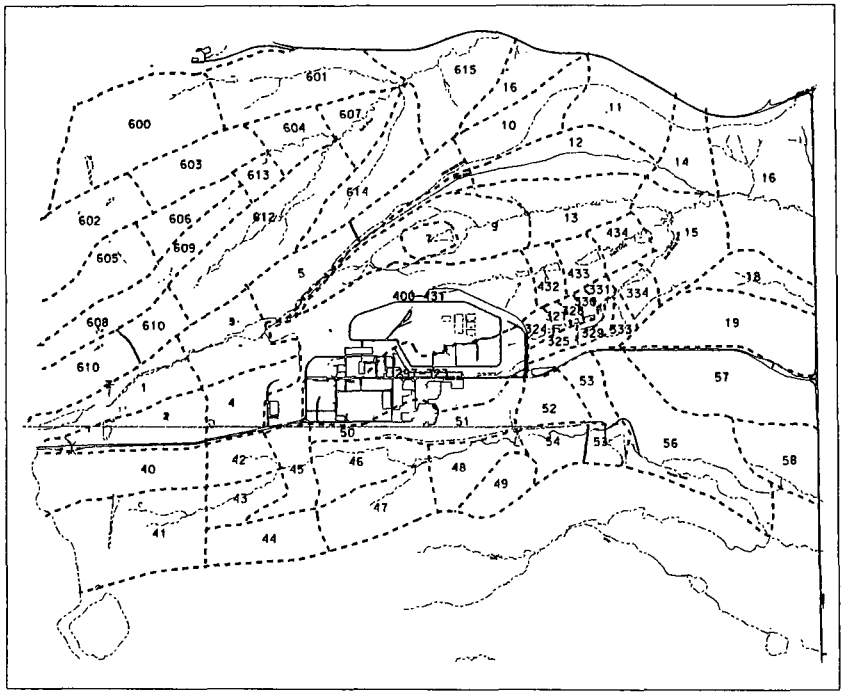

FIGURE 4
EXAMPLE LOCATION BASIN MAP

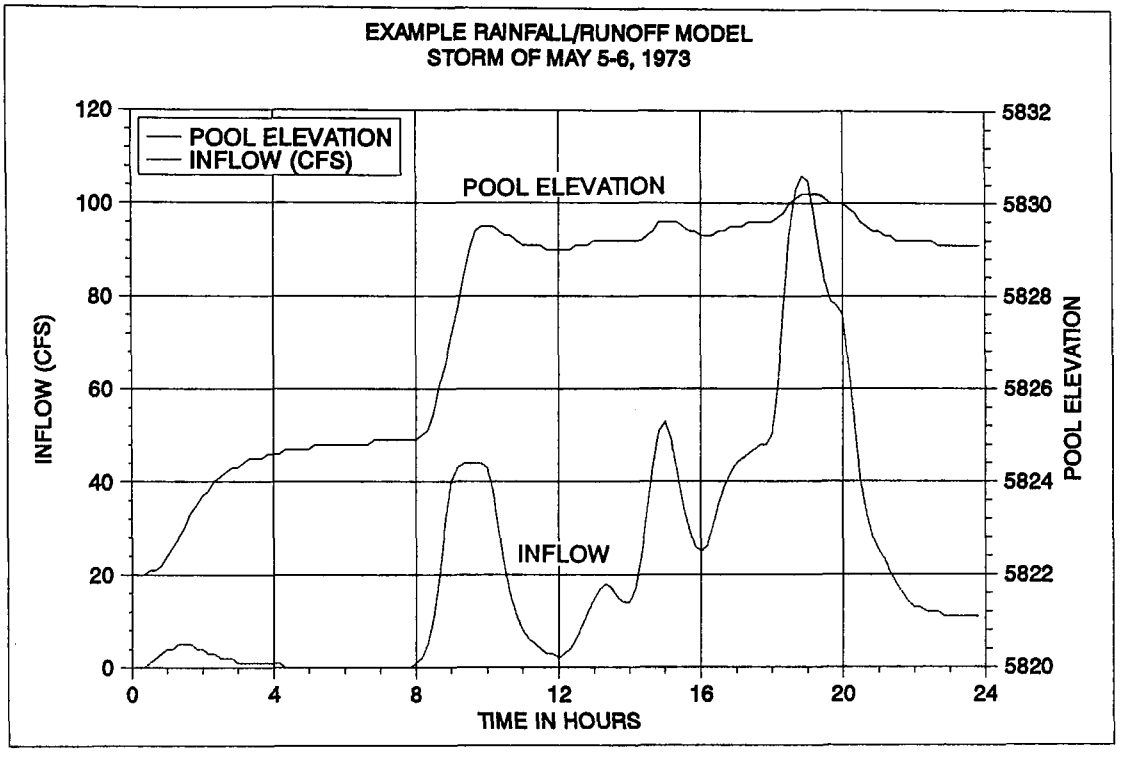

FIGURE 5
INFLOW HYDROGRAPH AND POOL ELEVATION

Erosion Potential- A site investigation should also be conducted upstream and downstream of the site to determine the potential for erosion problems resulting in contaminant transport. Velocities for surface water flow are required to determine the erosion potential in the area. Table 1 shows the suggested maximum permissible mean channel velocities for different types of channel material.

TABLE 1

SUGGESTED MAXIMUM PERMISSIBLE MEAN CHANNEL VELOCITIES*

CHANNEL MATERIAL	MEAN CHANNEL VELOCITY, FPS
FINE SAND	2.0
COARSE SAND	4.0
FINE GRAVEL	6.0
EARTH	
SANDY SILT	2.0
SILT CLAY	3.5
CLAY	6.0
GRASS LINED EARTH (SLOPES LESS THAN 5%)	
BERMUDA GRASS - SANDY SILT	6.0
- SILT CLAY	8.0

POOR ROCK (USUALLY SEDIMENTARY)	10.0
SOFT SANDSTONE	8.0
SOFT SHALE	3.5
GOOD ROCK (USUALLY IGNEOUS OR HARD METAMORPHIC)	20.0

*From EM 1110-2-1601

III. Baseline Risk Assessment

Baseline risk assessment is intended to provide an evaluation of the potential threat to human health and the environment from a hazardous waste site without any type of remediation. Hydrologic risk can be utilized to evaluate the long-term potential for surface water contamination. The hydrologic risk of having a flood event of a specified magnitude during a specified time period can be estimated by the following equation based on the binomial distribution theorem:

$$R = 1 - (1-P)^N$$

R = Total risk of flooding during specified period
P = Annual probability of a flood that exceeds a specified magnitude, ie;
P=.01 -- 100-year flood
P=.02 -- 50-year flood
P=.10 -- 10-year flood
etc....
N = Number of years that flood events could occur

An example may be a surface water impoundment such as a retention basin that had been built to collect and prevent contaminated sediment from entering a stream. The basin may have been built to hold the 50-year runoff from the upstream basin. Flows in excess of the 50-year storm would overtop the embankment and wash it away. The risk of having a 50-year storm is 2% for any given year. The risk increases over time and is shown in Figure 6. For example, there is a 33% chance of a 50-year flood occurring during a 20 year period. This type of analysis quantifies the risk of breaching the retention basin and contaminating downstream areas if there is no remediation efforts.

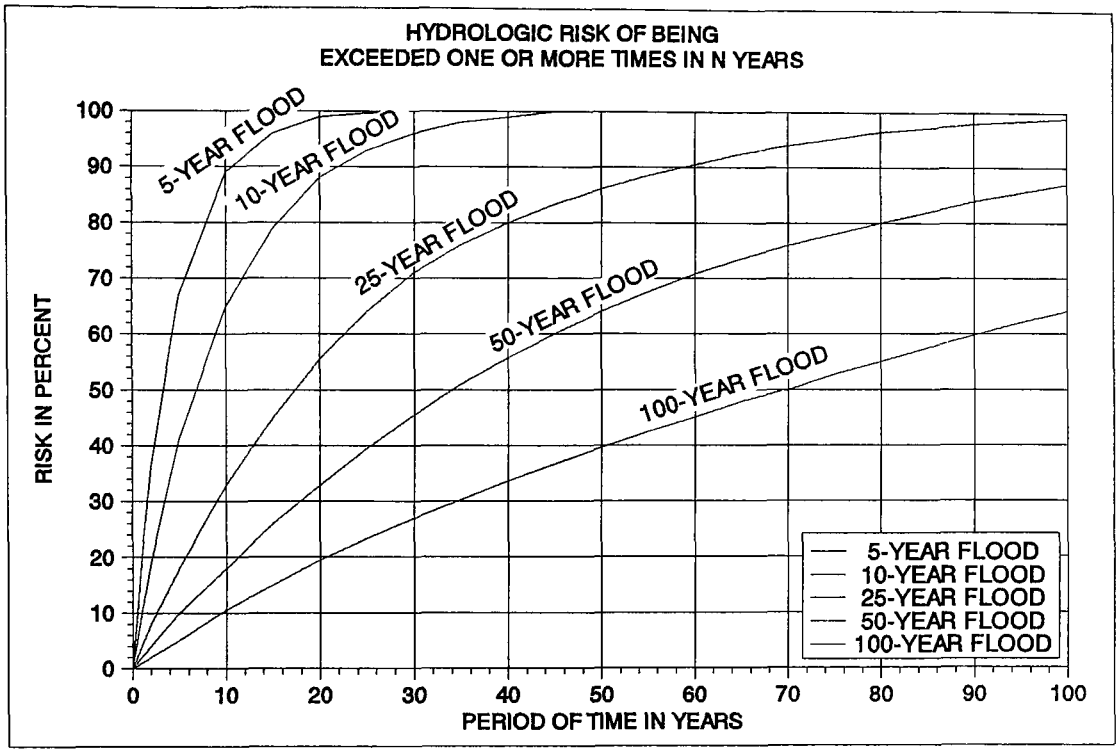

FIGURE 6
HYDROLOGIC RISK OF EXCEEDENCE

POTENTIAL HYDROLOGIC REMEDIATION DESIGN EFFORTS

Listed below are three different types of remediation efforts and various hydrologic analyses that could enhance the overall remediation.

I. Landfill Caps- The hydrologic areas of concern involving landfill caps are preventing erosion of the caps, providing adequate drainage away from the cap, and avoiding inducing flooding downstream of the site. Each site is unique and variables impacting the amount of runoff and erosion potential which need to be evaluated include the type of material, vegetative cover, the slope of the cap, the length of the slope, the final layout of the cap design, and whether the design will concentrate flows in any areas.

Typically, landfill sites are capped with either an impermeable clay cap or topsoil cap to prevent infiltration of rainfall. By promoting fast runoff of surface water from the cap, leaching of contaminants from the landfill through rainfall seepage is reduced or eliminated. However, promoting effective surface water drainage increases the peak rate of runoff from the area and may result in flooding

downstream of the site. A twenty-six acre hazardous waste site in Pennsylvania is used to demonstrate the increased runoff potential for an existing landfill area that is to be capped. A HEC-1 rainfall/runoff model was developed for the existing landfill and post-project capped landfill. As shown in Figure 7, capping the landfill doubles the peak runoff for the design storm, from 35 cfs to 80 cfs. The hydrographs also show how capping the area with impervious material increase the total runoff volume, represented by the area underneath the hydrographs. Also shown on Figure 7 is how using a five acre detention basin immediately downstream of the landfill cap can reduce the peak discharge back down to the original 35 cfs.

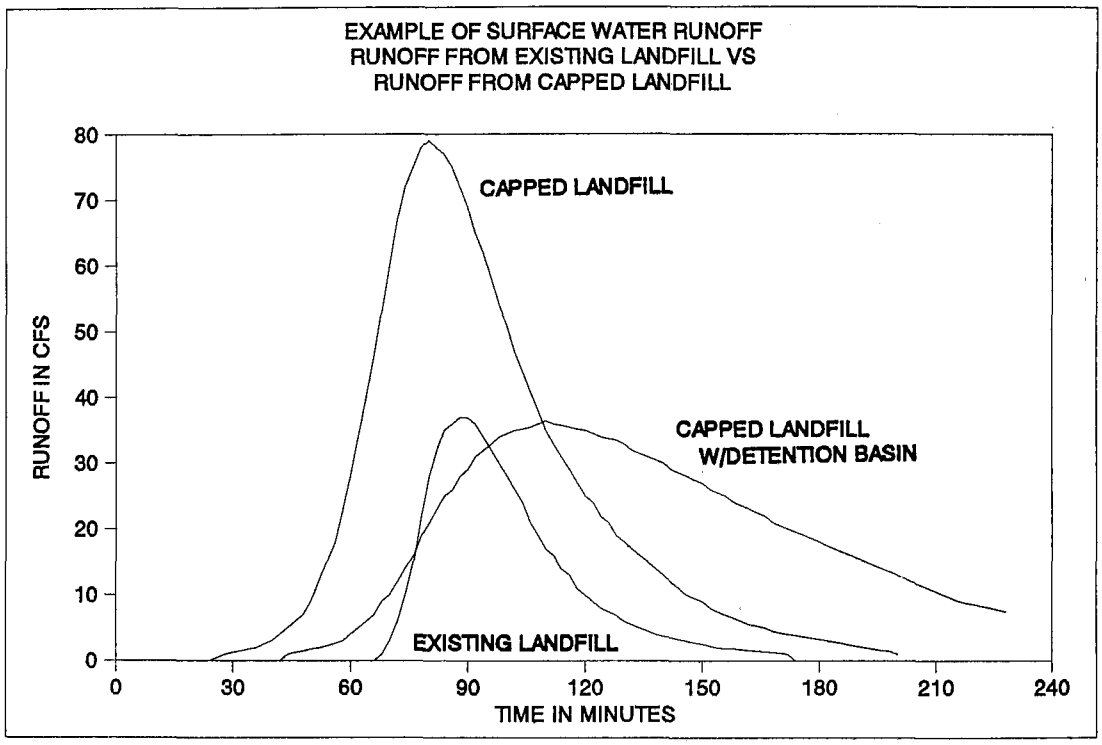

FIGURE 7
RUNOFF HYDROGRAPHS FROM LANDFILLS

The practice of proper drainage control in the design and construction of landfill caps is critical in preventing erosion and ultimately maintaining the long-term integrity of the cap. Most cap designs with steep slopes greater than 5% will require some form of collection system on the cap to drain the surface water. One system used is similar to a terrace in which the terraces are spaced out along the slope of the cap to intercept flow before it starts to concentrate and erode the cap. The intercepted flows are then directed to several central locations to be discharged down the slope of the cap. Caps with slopes greater than 5% must be pro-

tected because of the potential for erosion and gullying from the high velocities experienced on these steep slopes. One form of protection successfully used to drain water from the terraces are gabions. Gabions are flexible wire baskets filled with stone. Gabions will protect the cap from erosion and have some flexibility if settlement occurs to the cap. Other types of structures can also be used but the designer should be aware of the possibility of settlement causing cracking or deterioration of the fixed structure, allowing the high velocity flows to undermine the structure. At the bottom of the channel, energy dissipation must be provided to prevent erosion and scour damaging the toe of the cap.

Surface water runoff must also be conveyed away from the site into an established waterway or channel. This prevents the runoff from being confined and causing long term maintenance problems due to ponding against the base of the cap.

Problems may also arise from induce flooding when attempting to convey the surface water runoff away from the cap site. Almost every state and many local entities have laws and regulations dealing with changing site conditions to prevent upstream landowners from developing land in a way that would induce flooding on downstream landowners. Typically, the provisions require the upstream landowners or development may not increase the peak 10-year, 50-year, or 100-year flood flowrates off the site above the existing condition flow rates. If there is an increase in flowrates, detention basins, improving the downstream channel or other measures would be required to reduce the flowrates to the original existing conditions. Figure 7 in the example cited at the beginning of this section illustrates this concept.

II. Excavation in Floodplains- Frequently, if surface water is a pathway for contamination migration from hazardous waste sites, it involves the spread of contaminants via localized flooding from an industrial plant typically located several hundred feet from the receptor creek. As the localized or interior flood flows towards the creek it would encounter flat slopes and natural berms along the creek bank formed by deposition of sediment during floods. This forms a natural trap for the contaminants to settle out in the soils along the creek bank.

When the creek flows out of its banks during flood events, the potential exists for washing away the contaminants and contaminated soils in the overbank areas to downstream receptors. It is very critical to determine how often the creek will overflow its banks, the velocity of flow in the overbank areas, and the erosion potential of the

overbank areas.

Typical remediation of sites like this involve excavating the soils in the overbank areas and either treating or disposing of them off-site. Excavation of these areas without providing some means of flood control from the creek is potentially very dangerous because it could induce hazards on downstream communities. By clearing and grubbing the land before excavation, the erosion potential is greatly increased because of the removal of erosion resistant vegetation and the reduced roughness resulting in higher velocities. The existing surface areas before excavation would also probably be relatively clean and seasoned due to frequent inundation by both interior flows and overbank flows from the creek. Once excavation has begun, though, it exposes the potentially more contaminated soil beneath the surface that had not had a chance to be washed clean.

In terms of a remediation project's success or failure, it is interesting to compare the site's carcinogenic risk based on the site's cleanup level to the site's hydrologic risk of failing. EPA policy requires that Superfund sites be cleaned up to the level of excess risk of 1 per 1,000,000. In other words, an individual has a one in one million chance of developing cancer as a result of site related exposure to a carcinogen over a 70-year lifetime. In terms of hydrologic risk, though, the regulations state that for any given year, the washout of contaminants due to flooding can occur for floods greater than the 100-year flood event, or in terms of probability, 1 in 100 - far greater than the 1 in 1,000,000 chance of getting cancer. For comparison purposes, based on binomial distribution, the chance of flooding in excess of the 100-year flood during the 70 year lifetime of the individual is 50 percent. This analysis may be unfair, but the public will most likely perceive the project as a failure if there is any release of contaminants downstream anytime during the life of the project.

The excavation of hazardous waste sites located within the 100-year floodplain must be done with complete knowledge of the hydrologic risks associated with it. Factors that could impact on the success of this type of project include flood warning times, flood depths, flood frequencies, erosion potential on the site and the streambank adjacent to the site. Flood warning times can be used to evaluate the amount of time available to evacuate the site and cover or protect the exposed material. This is especially critical for small watersheds that have relatively short flood peaking times which provide little or no warning time. Evaluation of the erosion potential of not only the site but of the adjacent streambank is important. The banks of many streams can move hundreds of feet during a flood event if

the bank is not protected. Flood depths and frequencies are important because they can be used to locate the staging area and equipment out of the floodplain and stage the work so that as little time as possible is spent in areas affected by events less than the 100-year event.

If the construction must occur within the floodplain, it may be necessary to have a structural solution. Examples are levees, diversions, bank stabilization, floodwalls (temporary or permanent), detention ponds, and dams. A hydraulic analysis should be conducted to select the most cost effective solution. The impacts of the structures on the upstream and downstream floodplain must also be evaluated. An example of where levees or floodwalls could be used is when the site to be excavated is immediately adjacent to the stream bank and is subject to flooding from a 10-year event. The excavation is to be 5 feet deep in the floodplain adjacent to the channel. This situation should require a levee or floodwall be built up to the 100-year level of protection to prevent the site from being inundated from events as low as the 10-year event. Using this same example, if the streambank is unstable and it erodes into the site during excavation, a serious problem would develop. Armoring of the bank with riprap or other material in conjunction with the levee may be desirable. An example of where a dam could be used would be the case where it is desirable to contain contaminated sediments and prevent their migration downstream. Depending on the size of the watershed, a small dam could be built to hold back the sediments and prevent them from being washed downstream.

<u>III. Wetlands Restoration</u>- Many environmental restoration projects impact wetlands and some sort of wetlands restoration is frequently required. Hazardous waste site remediations frequently involve excavation of soils in wetland areas and remediation designs often times cover up existing wetlands. Established hydrologic techniques can be used to analyze the existing wetlands and to develop mitigation plans for replacement wetlands.

Wetland restoration must begin with a thorough understanding of the baseline existing hydrologic condition of the wetland. For many wetland sites, this involves analyzing how the existing wetland functions during cycles of extreme drought and flooding conditions over a long term time period. Typically, this can be demonstrated in what are known as a surface area-duration curve and a depth-duration curve as shown in Figure 8. Because there are rarely gaging

stations in smaller wetlands, the duration curves must be developed through hydrologic modelling.

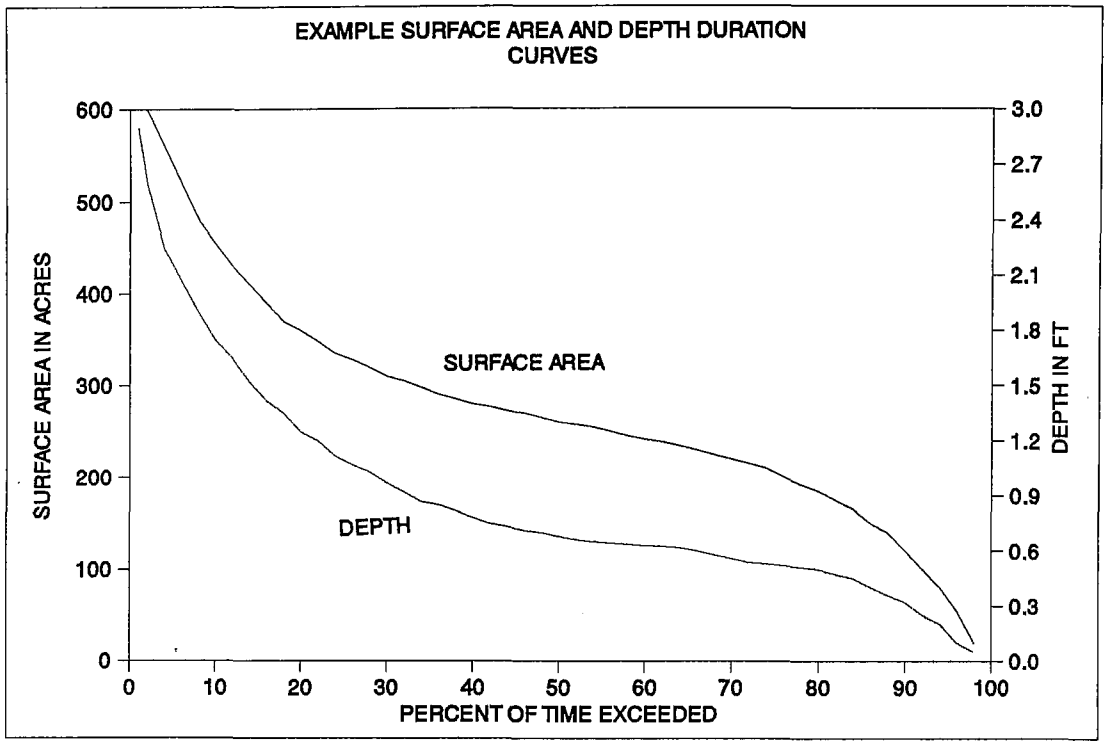

FIGURE 8
SURFACE AREA-DURATION AND DEPTH-DURATION CURVES

The hydrologic modelling necessary to define baseline hydrologic conditions involves determining the daily water budget for the wetland. This involves accounting for the surface water inflows, outflows, precipitation, evaporation, and seepage on a daily basis. The surface area-duration curve shown on Figure 8 for a typical midwestern wetlands was derived by using the Streamflow Synthesis and Reservoir Regulation (SSARR) computer program which was developed by the North Pacific Division of the Corps of Engineers, to calculate the daily flows into the wetland. The actual daily water budget was estimated using the Omaha District's Wetlands Hydrologic Analysis Model (WHAM). These two models were used to simulate the daily inflows, outflows, evapotranspiration, pool levels, surface areas, average depths, and pond volumes over a twenty-one year period.

Once the baseline hydrologic conditions of the wetland has been determined, any mitigation plans could be analyzed with the same type of analysis over the same historic period. This would give an indication of how effective any mitigation plans would be in duplicating the existing wetland's long term depth and surface area durations. If the curves

do not match up very well, mitigation plans could be modified. This modification could involve changing the outlet control of the wetland, regrading the wetland, etc. Figure 9 shows how the comparison could be easily summarized in average annual surface area for the different wetlands conditions.

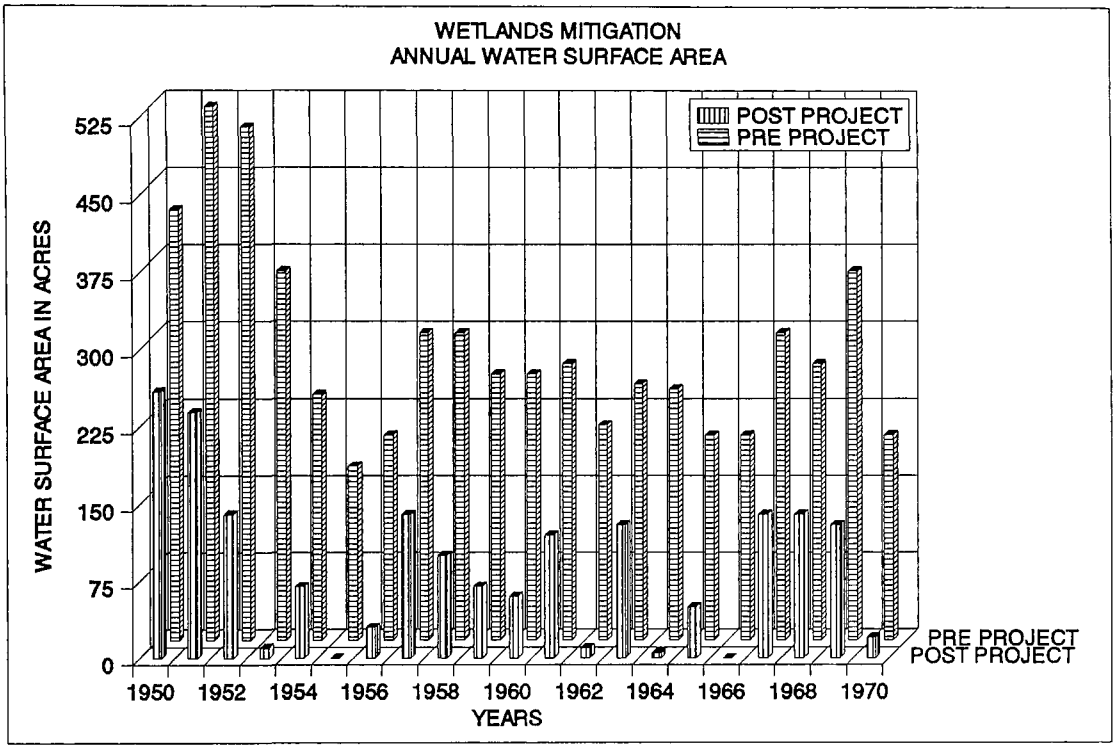

FIGURE 9
AVERAGE ANNUAL WATER SURFACE AREA

CONCLUSION

Recently, several completed cleanup sites have encountered problems associated with some form of hydrologic design deficiencies. These problems include excess water ponding up against the base of a landfill cap, surface water detention basins that were originally undersized and had to be enlarged, improperly designed drainage channels on landfill caps, etc. There also exists the potential for problems with cleanup sites that are being constructed in floodplains. These problems involve potential erosion problems that may transport contaminants downstream during flooding events. These sites were designed without a full appreciation of the dynamic nature of river systems, and in some cases, no hydrologic analysis at all. These problems can be

avoided if they are identified early in the investigation and design processes and can be solved with a minimum of design effort utilizing established techniques and methodologies.

APPENDIX 1 - PERTINENT FEDERAL REGULATIONS

<u>40 CFR Part 6, Appendix A - Statement of Procedures on Floodplain Management and Wetlands Protection</u> - This regulation essentially states that Federal agencies are required to evaluate the potential effects of actions it may take in a floodplain to avoid adversely impacting floodplains whenever possible. Specific requirements involve:

1. The Federal agency must determine whether or not the proposed activity will take place in a floodplain.

2. The public should be informed when it is apparent that some sort of Federal action is likely to impact a floodplain.

3. If an action takes place in a floodplain, a floodplain assessment should be performed. This would include a description of the action, the effects on the floodplain, and a description of the alternatives.

4. Public review of floodplain assessments.

5. If there are no alternatives to affecting the floodplains, actions should be taken to minimize potential harm and act to restore and preserve the natural and beneficial values of the floodplains.

6. Agency decision.

<u>40 CFR Part 264.18 Location Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities</u> - This regulation states a TSD facility located in a 100-year floodplain must be designed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood. Specific definitions include:

1. Facility- "All contiguous land, and structures, other appurtenances, and improvements on the land, used for treating, storing, or disposing of hazardous waste."

2. 100-Year Floodplain- "Any land area which is subject to a one percent chance or greater chance of flooding in any given year from any given source."

3. Washout- "The movement of hazardous waste from the active portion of the facility as a result of flooding."

4. 100-Year Flood- "A flood that has a one percent chance of being equalled or exceeded in any given year."

APPENDIX 2 -- REFERENCES

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Design And Construction Of The Groundwater Treatment Plant At The Conservation Chemical Company Site

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INTRODUCTION

The design-build concept is not new to engineering, but it is new as an approach to the remediation of hazardous waste sites. The benefits of this approach are concentrated in better communications (single point of control), shorter schedules and control of costs. While these benefits can apply to any engineering project, the approach itself tends to conflict with the review procedures and schedules most agencies are using for hazardous waste projects.

For clients and reviewing agencies who are not familiar with design-build, the concept of combining engineering and construction under one roof is seen as a break down of the traditional checks and balances of engineer/contractor relationships. The approach focuses on critical path scheduling, preparing less detailed engineering drawings and specifications, shortens procurement times, and moves some engineering into the construction phase. No benefits, however, can be gained from the approach if the approval process does not move along the same fast track or without an understanding that less detail in drawings does not mean less quality in the field. Mistrust must be overcome, that quality in design and/or construction will not be less, but that a professional approach to design-build can yield benefits to all involved.

Remediation of hazardous waste sites invariably involve multiple reviewing agencies. The time and money that can be saved by the design-build concept can quickly be lost if those reviewing the projects cannot provide quick turnaround of reviews, hold to schedules and make timely decisions. One of the major time savings can be in an accelerated procurement schedule. Major equipment items and/or long lead time items, can be purchased with performance specifications and direct negotiations rather than developing complete bid documents. This time benefit is lost though if portions of projects cannot be approved separately as design progresses and reviewers wait for an entire design to be complete prior to giving any approvals. Additional savings can be gained in that drawings do not have to be prepared to the detail a traditional bid set would have been because some of the engineering can take place in the field in some instances more cost effectively than in the office. This could mean preparing only one-line piping drawings rather than isometric drawings and leaving the details of the pipe runs to be layed out and designed in the field. This savings can easily be lost without timely approvals of design concepts and acceptance of less than normal detail in engineering drawings. This is a change from the traditional method of reviewing full sets of detailed drawings and specifications.

It is imperative that all the parties involved in the future remediation of hazardous waste sites understand the design-build process and adjust their thinking and procedures to fully gain the benefits it can provide to a project. "Time is of the essence" in many of the projects that both the public and private sector want remediated. The design-build approach can provide this.

The remediation of the Conservation Chemical Company site in Kansas City, Missouri is a good example of how the design-build concept can work if all parties involved are committed to the process and responsive to its needs. This project involved design and construction of a groundwater treatment plant with seven separate reviewing parties, a tight Consent Decree schedule with penalties for non-performance, and a lump sum contract. The project met all its technical, financial and schedule milestones.

BACKGROUND

ABB Environmental Services, Inc. (ABB-ES) headquartered in Portland, Maine, designed, constructed and started-up the Front Street Groundwater Treatment Plant (former Conservation Chemical Company site) in Kansas City, Missouri for the Front Street Remedial Action Corporation (FSRAC). The treatment plant operates 24 hours a day pumping groundwater at an average rate of 164 gallons per minute (gpm) and a maximum rate of 300 gpm to the 5-step treatment train which removes organic chemicals, such as TCE and PCE, as well as heavy metals such as cyanide and lead.

The job site was approximately rectangular with dimensions of 790 feet by 330 feet. The property is on the riverside of the levee bordering the Missouri and Blue Rivers. The site is a relatively flat-topped mound that slopes gently toward the Missouri River and lies approximately 10 to 15 feet above the surrounding flood plain.

The site geology consists of Pleistocene and Recent (Holocene) deposits. These deposits strongly influence the character of the soils and aquifers formed within them. Loess deposits, glacial till, and residual soils overlie the bedrock immediately adjacent to the Missouri River and are widespread north of the river. Bedrock, found at approximately 160 feet below the surface, is overlain by Missouri River alluvial deposits.

For about 20 years, beginning in the early 1960's, the Conservation Chemical Company (CCC) in Kansas City, Missouri processed chemicals at its plant situated on the flood plain near the confluence of the Missouri and Blue Rivers. During this period of operation, the primary materials accepted by CCC were spent acids, alkalies and other caustics, metals and metal sludges, liquid and solid cyanides, organic solvents, and halogenated compounds. CCC also accepted spent oil, inorganic salts (liquids and sludges), elemental phosphorus, pesticides, herbicides and small quantities of miscellaneous organic compounds. The company employed a variety of waste handling practices, including cyanide incineration, solvent incineration, pickle liquor neutralization, cyanide complexation, chromatic acid reduction, ferric sulfate/ferric chloride recovery, and bulk liquid and solid disposal. The residuals from the processes were generally disposed of on site in six detention basins. Drums, bulk liquids, sludges and solids were buried on the site. It is estimated that 93,000 cubic yards of materials were buried on the 6 acre site.

For approximately three years in the late 1970's, a portion of the sludge by-product in each basin was mixed with fly ash and pickle liquor for stabilization and a thin layer of clayey material was placed over a portion of the site.

Results obtained from site investigations indicated that materials were migrating from the site via groundwater. There were 21 substances identified that were substantially in excess of applicable criteria or standards for water quality. These included metals, cyanide, phenolic compounds and volatile organic compounds. The concentrations of these materials in the groundwater decreased substantially down gradient of the site as a result of dilution, dispersion, degradation, and absorption. The geohydrologic investigation of the site showed that groundwater flows toward, and discharges into the Missouri and the Blue Rivers.

The greatest risk was determined to be the potential release of these materials into the groundwater over time. Groundwater is used as drinking water within a two mile radius of the site. Secondary risk was considered to be from contaminated soils which may be transported by precipitation runoff into surface water bodies or the groundwater.

A number of remediation alternatives were studied. Most were quickly eliminated leaving three main alternatives to pursue. They were slurry wall containment with interior pumping; on-site containment by pumping and groundwater treatment; and excavation followed by soil treatment. The 1987 Record Of Decision (ROD) chose a remedy that included the use of a permeable cap to allow water intrusion to assist groundwater clean-up, a withdrawal well system to achieve an inward groundwater gradient, a groundwater treatment system based on several unit operations and off-site groundwater monitoring.

More than 200 contributors to the site had been previously identified as Potentially Responsible Parties (PRPs). Settlement negotiations between the Original Generator Defendants and the U. S. Government resulted in the signing of a Consent Decree for remediation of the site. Four companies joined to form the Front Street Remedial Action Corporation. These companies were FMC Corp., AT&T Technologies Inc., IBM Corp. and ARMCO Inc. Total clean-up costs were estimated to be in the order of $30 million in 1988 dollars. The design and construction of the treatment facility was accomplished for approximately $4.7 million.

ABB Environmental Services, Inc. began work on the Front Street Project in December, 1988. Following surface clean-up and installation of a permeable cap by other contractors, the final design was prepared and submitted to the U.S. EPA for review on April 27, 1989, five months after the contract was signed. Construction began in June of 1989 and substantial completion was obtained in March, 1990, on time and under budget.

Since the plant's start-up in May 1990, the Front Street Groundwater Treatment Plant has met Federal and State effluent discharge guidelines and performance expectations.

MANAGEMENT APPROACH

There were two major issues to be faced for this remedial design and construction project. The first, and most difficult was managing the project through a multitude of reviews and reviewing parties while still meeting the mandated contract deadlines. The second issue was the technical complexity and construction limitations of the site.

The contract time periods for the project were tight considering the number of parties requiring review and approval of work products. The contract stipulated that design of the groundwater treatment plant be complete within 5 months, that construction be substantially complete within 15 months of contract signing and that the entire work be completed within 16 months of contract signing. During the design phase, a treatability study was also required to be conducted to verify the anticipated effectiveness of the various treatment unit processes.

The reviewing parties were many and varied. They included the following:

- U.S. EPA Region VII
- U.S. EPA's independent reviewing engineer
- Four - PRP clients who had formed the Front Street Remedial Action Corporation
- The PRP oversight engineer
- Missouri DNR
- U.S. Army Corps of Engineers

- City of Kansas City, Missouri

The project required gaining approvals from all these parties, the contract and Consent Decree stipulated liquidated damage penalties for delays beyond specified contract times for design and construction, and it required design verification through treatability tests. All this was performed for a lump sum design-build contract price.

A design basis was developed by FSRAC's oversight engineer prior to the solicitation of bids for the Design-Build Contract. This document provided the general basis on which the remedial action was to be designed with the exception of an Operation and Maintenance Program or plan which was to be developed as part of the Design-Build Contract. The groundwater treatment facility consisted of five treatment processes and their housing, installation of a groundwater collection system from the withdrawal wells, installation of four paired piezometer instrumentation units, and utility services required by the well systems. Equalization, metals hydroxide precipitation, biological treatment, activated carbon, and metals removal by sulfide treatment were specified to be used to treat the groundwater. The treatment plant was designed to operate 24 hours a day with one manned shift operation 5 days per week.

To meet all the project deadlines and requirements, it was imperative that communications be frequent and precise. ABB-ES accomplished this by three basic steps: (1) meetings were held with all parties on a minimum of a monthly basis; (2) a manual of procedures was developed to provide a framework for communication and decision making among the parties involved; and (3) a design criteria document was created to serve as a continuously updated statement of design decisions. In addition, project management had to be thorough and consistent through both the design and construction phases of the project. It is particularly important in design-build projects that information and decisions made during design are carried into the construction phase by continuity and consistency in the management of the project.

The result of these initiatives which were rigorously followed throughout the design-build process, was that all parties were cognizant of exactly what was being accomplished throughout the process. Alternatives and treatability results were openly discussed, relative merits reviewed and decisions made on a timely basis. The fact that all parties were frequently involved as the design process progressed allowed for a short review time at the end of design. The final set of documents became a culmination of decisions previously discussed and agreed upon with no surprises for anyone.

TREATABILITY

Concurrent with the design of the Groundwater Treatment Plant, treatability studies were required. The purpose of the studies was to verify the anticipated effectiveness of the various treatment unit processes, and the overall design targets for effluent quality. Design targets were based on a draft NPDES permit.

A number of groundwater wells had been installed on and around the site and samples analyzed for compounds and concentrations at those locations. Predictions then had to be made as to the concentrations that would occur at various pumping rates at the two proposed extraction well locations. Weighting factors were established through analytical methods for this purpose.

Groundwater samples for the treatability study were collected from nine wells. Composite samples were then prepared to simulate the predicted composite expected at the withdrawal wells by using the predetermined weighting factors. The composite samples were then used in a laboratory treatment system to simulate, as close as possible, the full scale specified treatment system.

In order to meet the schedule and purpose of treatability, the laboratory equipment used for the study was built as close to scale as practical. Lancy International worked with ABB-ES as a subcontractor on this portion of the project. The system was operated at a scale flow rate of 300 gpm with an actual flow rate of 80 ml per minute. A process flow diagram for the treatability testing is shown in Figure 1. The process included the following chain: equalization tank with air mixing, pH adjustment, flash mix tank, flocculation tank, clarifier, pH adjustment #2, bio-tower, gravity filter, carbon columns and sulfide system. The pilot system was designed to simulate the performance of the treatment system operating at 300 gpm. To determine the performance of each unit operation, samples were collected from seven sampling points in the system. Two grab samples were collected daily from each point for five days. Each sample was carefully collected, stabilized and analyzed.

A brief description of the process chain and results of treatability follows. Figure 2 depicts the treatment process described.

1. Equalization

Groundwater extracted by two well pumps is transferred to the equalization tank. The equalization system serves two purposes; oxidation of ferrous iron and equalization of the groundwater sources as they are pumped to the system. An air diffuser is employed to aid the oxidation process in the equalization tank. Testing confirmed the air requirements for complete oxidation of the iron.

2. Metals Precipitation

The metals precipitation system consisted of pH adjustment reactor, rapid mix tank, flocculation tank and clarifier. Groundwater from the equalization stage overflows into pH adjustment tank #1. The testing confirmed pH levels and detention times for proper operation. Both lime and sodium hydroxide were tested for neutralization. The amount of agent needed, and quantity of solids generated by each agent was determined and used in a subsequent capital and operational cost analyses. Lime was subsequently selected as the most cost effective agent for the process.

Groundwater for pH tank #1 overflows to the rapid mix tank. Here an anionic polymer is added to aid the metals precipitation process. From the rapid mix tank, the groundwater overflows to the flocculation tank. Flocculation provides proper conditions to permit the small sludge particles formed in the neutralization process to agglomerate and grow into larger particles.

Flocculated groundwater flows by gravity to the plate packed metals clarifier. The clarifier is the final link in the metals precipitation chain. Here the final separation of solids from the effluent takes place. Treated effluent overflows from the clarifier and into pH adjustment tank #2. Thickened sludge is withdrawn automatically from the metals clarifier and pumped to the metals thickener for thickening prior to disposal.

Results of testing showed that all metals were precipitated to levels below the effluent limitation required for discharge.

3. Biological Treatment

Effluent from pH tank #2 is pumped to the splitter box and then to the aerobic bio-tower system. Cultured micro-organisms (inoculum) are housed in the packing media and serve to

digest organic matter. The bio-towers are continuously supplied with nutrients to enhance the biological treatment.

Testing indicated that the bio-system was able to remove all measurable quantities of volatile organics. In addition, it was found that phenols were reduced from 13 mg/l to 0.12 mg/l. COD and BOD showed similar magnitudes of reduction. Effluent showed very small amounts of total suspended solids.

From the data collected, two 12-foot diameter towers with a height of 20 feet were selected.

Of major importance from this portion of the treatability study was the fact that virtually no sludge was produced by the bio-towers except that which adhered to the packing. Estimates were that only approximately 100 pounds of sludge per day would be produced at a flow rate of 300 gpm. The result of this was that the originally proposed bio-system clarifier, thickener and filter press were eliminated from the flow scheme saving the client time and money.

4. Gravity Dual Media Filtration

Effluent from the bio-towers overflows to the dual media filter for removal of solids prior to carbon filtration. The filtration system consists of anthracite and sand as filtering media. The system includes an automatic backwash system which enables the filter to clean itself with no shutdown involved.

5. Activated Carbon Filtration

Following gravity filtration, the effluent is collected and pumped to the carbon filtration system. This system of 2 filters is employed for removing soluble organic chemical contaminants from the groundwater using granular activated carbon media. Due to the excellent performance demonstrated by the bio-towers, the load on the carbon columns was expected to be very low.

6. Sulfide Precipitation

The sulfide precipitation system is used to remove both chelated and non-chelated heavy metals. Filtered effluent from the carbon columns is pumped to a pH adjustment tank where the pH is raised to between 9 and 9.5. Following pH adjustment, a soluble sulfide is added to the reaction tank where most of the complexed heavy metals are converted to insoluble metal sulfides. From the reaction tank, the groundwater is pumped to the filter columns containing a media which removes insoluble metal sulfides and adsorbs the incipient nuclei of underacted metal sulfides. In addition, the reactive media also sorbs free excess sulfide ions and adsorbs, or chemisorbs, metal ions or metal/organic complexes, producing a final effluent of extremely high quality.

Following sulfide treatment, the effluent overflows to the final pH adjustment tank and then is discharged to the Missouri River.

In addition to confirming the effectiveness of the various treatment processes, the treatability study yielded information necessary for sizing the sludge handling processes. A brief description of the sludge handling facilities provided is as follows.

1. Gravity Thickening of Metals Precipitation Sludge

Solids generated in the metals clarifier are withdrawn automatically and pumped to the metals thickener. The metals thickener is a secondary gravity settler in that it receives the underflow from the primary settler or clarifier, in this case, the metals clarifier. The objective of increasing the solids in the underflow from the primary clarifier is to facilitate the further dewatering and disposal of the sludge.

2. Gravity Thickening of Sulfide Sludge

Solids generated in the sulfide system filters are withdrawn and transferred to the spent media thickener. The sludge/media discharge is in the form of a slurry, which is allowed to thicken before final dewatering and disposal.

The metals and sulfide sludges were purposely separted. Treatability testing indicated that the sulfide sludge might need special disposal where the metals sludge may not. This could provide a significant operational savings.

3. Filter Press Dewatering of Metals Precipitation Sludge

When sufficient sludge exists in the metals thickener, the sludge is dewatered. Sludge is pumped into the metals filter press at high pressure. Under pressure, the sludge particles begin to deposit on the surface of the filter cloth to form a thin precoat layer. When the filter cloth has been precoated with the sludge particles, this precoat layer then becomes the filtering medium, and as filtration continues, a filter cake gradually builds up within the chamber formed by two adjacent plates. When the complete plate chamber has become packed into a hard sludge cake and the filtrate flow has dropped away to virtually nothing, the press is ready for cleaning. At this point, the press feed pump is stopped and the back pressure in the press relieved through a relief valve located at the fixed end of the press. At this point, the plates are separated, allowing the filter cake to fall into a dumpster for final disposal.

4. Filter Press Dewatering of Sulfide Sludge

When sufficient sludge exists in the spent media thickener, the sludge is dewatered similar to the metals sludge using the spent media filter press. The dewatering process is similar to that listed in the metals precipitation description.

The analytical results of treatability confirmed the reductions in heavy metals, cyanide, volatile organics, phenols, pesticides and other organics and miscellaneous compounds. Operational flow rates and equipment sizes were confirmed during this process. Sludge handling and chemical usage were determined for plant operations. An example of treatment system performance results obtained during treatability are included in Figures 3 and 4.

DESIGN

The design process proceeded concurrently with the treatability study. This had to be done in order to meet Consent Decree schedules even though some efficiency was lost since assumptions had to be made on various equipment sizes prior to receiving the final results from treatability.

ABB-ES employed several measures that increased communication and design efficiency.

ABB-ES' first priority during the design phase was to assemble a manual of project procedures to provide a framework for communication and decision making among the parties involved with the project. The manual was reviewed by the FSRAC Committee, the Owner's engineer and U. S. EPA and its consultants.

In addition to the procedures manual, a Design Criteria Document was developed. This document contained the following: process design data including a process description, capacity, raw water quality, effluent quality and detailed equipment criteria; detailed design criteria in the areas of geotechnical, piping and mechanical, structural, HVAC, instrumentation, electrical, and civil; plant flow hydraulics; equipment motor list, and catalog cuts of all major pieces of equipment to be installed.

This Design Criteria was updated on a monthly basis as the design proceeded and was distributed to all parties for review. It became a living document that served as a continuously updated statement of design decisions and ultimately evolved into a specifications document.

It was through these two documents along with progress drawings, that all reviewing parties were kept continuously informed and updated on the progress of design. There were no surprises at the conclusion of design. Each review issue simply became a confirmation of discussions and conclusions made during regularly scheduled meetings. This process significantly reduced review time throughout the design.

The initial stage of design was to perform the hydraulic flow calculations, initially size equipment and prepare general layout drawings. This was performed at the same time the treatability testing was being accomplished. The use of CAD made this economically feasible since changes could quickly be made as results from treatability confirmed or revised equipment sizing. The area allowed for construction of the treatment plant was severely limited. A pad of approximately 100 feet x 170 feet was provided so the treatment system had to be fit in a building that was 90 feet x 120 feet. The original design basis had called for a totally gravity fed system. After reviewing this concept, the layout and estimating the cost required for a total gravity fed system, ABB-ES prepared an alternative system for consideration consisting of adding two pump stations with redundant pump systems and presented this approach with a cost analysis to the FSRAC Committee. The result of the alternative was to significantly lower in elevation a number of the initial process systems (equalization, clarification and filtration) and provide a lower profile building and more efficient floor layout. This alternative saved the client money and ultimately saved construction time as well and was accepted and became the basis for final design.

The treatment building is a steel structure 90 feet x 120 feet in size with insulated metal roofing and siding. The structure is heated and ventilated. It houses all processes with the exception of equalization, biological and the air blowers. All equipment is installed above grade with no buried tanks or deep sumps. Floor drainage is collected in shallow sumps and trenches and pumped back through the treatment system. Localized exhausts were supplied for the sulfide make down tank and ammonia tank. An office area was provided to contain the electrical control panel and PLC control system.

The control system provided for the project consisted of a Square D Model 400 PLC for discrete and analog control. To assure continued system control in the event of main processor failure, a second Square D Model 400 PLC for "hot backup" was provided. All digital inputs and outputs, as well as all P&ID loops have individual discrete and analog input and output process control points.

The following scenario describes the basic plant operation. The groundwater treatment system operates whenever the extraction wells are operating. Pumping rates for the extraction wells are based

on the gradient obtained at the four paired piezometer stations located on the perimeters of the site. When the wells shutdown, the treatment system does as well. Various high and low level alarms throughout the unit processes can also cause a system shutdown. The plant is designed such that if there is a shutdown, groundwater in the system flows back to its previous tank by gravity. All tanks and equipment are sized for this additional capacity.

One main electrical control panel is provided in the control room. Separate control panels are provided in the field for the filter presses, the sorption filter, the lime silo and the dual medial filter, to assist the operator in running the plant.

The PLC system was supplied with a screenware package with data logging, a printer, PC with color monitor and membrane keyboard. Ten screens were developed to portray the process flow and provide data logging and alarm status generation. All alarm printouts and process operation can be reviewed from the operator's control panel.

The total design process took five months. This included performing and reporting the Treatability Study, preparing the Design Procedures and Design Criteria documents and preparation of 50 design drawings.

To expedite the design review and keep all reviewers comfortable with the amount of detail they were receiving during the design process, meetings were held on a tight schedule. ABB-ES, along with the FSRAC Committee made every effort to keep reviewing agencies informed of decisions that were made and results of treatability. Agencies or their representatives were involved in all the meetings. This was extremely important to the design-build process since the level of detail supplied in drawings and specifications tended to be less than the agencies were used to seeing in a traditional design-bid process. All parties were invited and encouraged to attend all meetings. This included the FSRAC Committee, their oversite engineer, the U.S. EPA and their consulting engineer.

Close communications by regular meetings, and the review and updating of the design criteria and drawings as the design proceeded resulted in approval of the final design granted by the EPA in 26 days.

CONSTRUCTION

Procurement for major pieces of equipment began during design, following completion of the Treatability Study. This was necessary to meet mandated schedules. Long lead items, such as the carbon columns, had to be put into manufacture well before final design approval was given.

ABB-ES' foremost concern when construction began in June 1989 was the small size of the working area, making it crucial to coordinate equipment deliveries with the construction sequence. Construction was scheduled and monitored using the Primavera Construction Scheduling software. This aided in identifying potential problem areas and re-scheduling tasks that had to be coordinated with other contracts working on-site.

The clean working area provided was approximately 100 feet wide by 170 feet long, while the treatment building was 90 feet by 120 feet. There was little additional room for staging. Various pieces of equipment - such as the equalization tank and the towers for the biological treatment step - were placed outside the plant, taking up another 40 by 90 feet.

Prior to the start of any on-site work, all the necessary permits and approvals had to be obtained. This became no easy task due to the number of agencies involved and was critical to meeting mandated schedules. In addition to obtaining approval from the U.S. EPA, the following additional

permits were needed: Missouri Department of Natural Resources, the U. S. Army Corps of Engineers and the City of Kansas City, Missouri.

Communication with all of these agencies began early in the design stage. Again, the need to educate everyone involved in what was proceeding and how, was particularly important in order to keep approval and review time to a minimum. A number of informational meetings were held prior to formal submittals to insure that all documentation and information was included in the submission packages and that the reviewers were familiar with the level of detail that would be supplied in the design-build package. The planning, communication, and education process paid off with construction permits issued by the Corps of Engineers and City of Kansas City within two weeks of formal submittals. This is particularly good considering the added complication that we were constructing the plant in a flood plain.

Construction began on-site in June of 1989. ABB-ES completed the excavation and concrete work first, followed by the erection of the treatment equipment. Scheduling was such that most equipment items were delivered and set in place immediately. Some smaller items such as pumps and blowers, were staged off-site and delivered as required during construction. The steel building structure was delivered after the installation of the equipment, and "wrapped" around the treatment systems. (Refer to Figure 5)

Throughout the construction phase, ABB-ES maintained its close coordination and communications with weekly site meetings and major monthly reviews on-site with representatives of the FSRAC Committee and reviewing agencies. Progress was reported and budgets updated, as well as reviewing critical item delivery schedules.

Once the building structure was in place, piping, electrical and instrumentation work proceeded at a fast pace. Piping was prefabricated as much as possible in the shop or on the plant floor and erected as unit assemblies. Pipe racks were specifically designed and located to allow as much clear space in the tight building as possible. Electrical cable tray was placed on the top of the racks with pipe hanging from below. (Refer to Figure 6)

ABB-ES obtained substantial completion of the treatment plant in March, 1990 - on time and under budget. During subsequent start-up and performance testing, the company provided on-site operator training and was responsible for preparing an operations and maintenance manual.

CONCLUSIONS

The Front Street Project, with its Consent Decree imposed schedule and limited construction area, posed a series of technical and managerial challenges for ABB-ES. Meeting those challenges and completing the treatment plant on time and within budget reflects the commitment that was made to communicate with and educate all parties on the design-build concept.

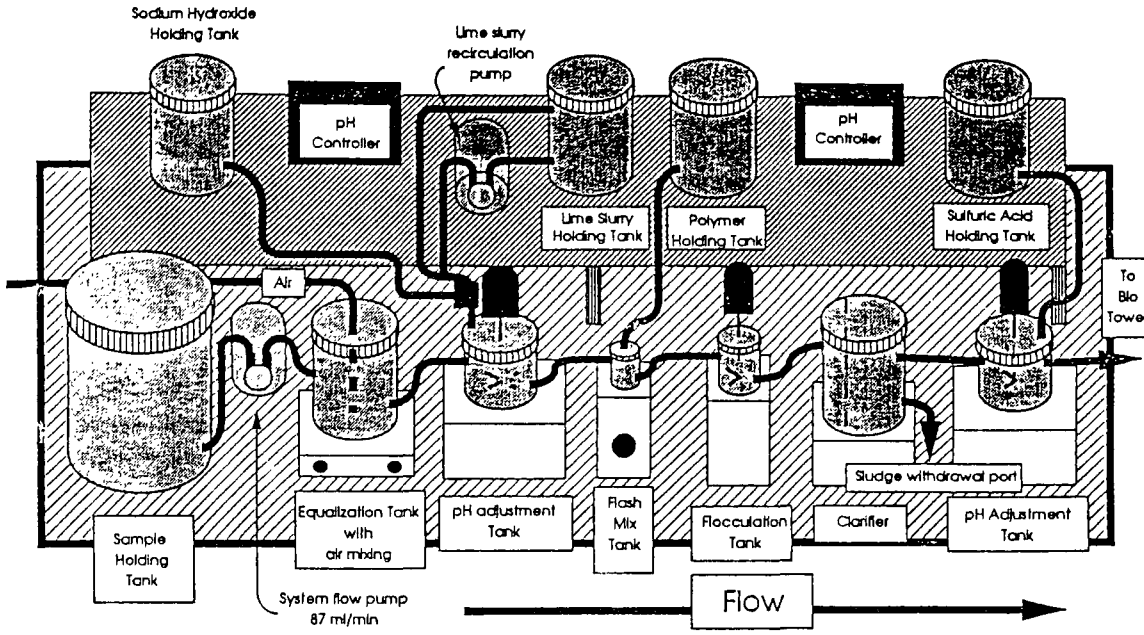
It is imperative that all the parties involved in the process understand exactly what level of detail will be provided in the design documents and how engineering proceeds into the field on these types of contracts. This is where the Procedures Manual and Design Criteria document became so important to the process. A complete understanding of procedures and documentation must be attained up-front in the job or unnecessary delays and duplication of effort can occur.

Along with a clear understanding of the process, trust must be developed during the process as well. Excellent management, communication and professionalism must be present for any project to proceed successfully, but it is even more important in design-build.

The net result of the Front Street Project was the design and construction of a remedial action that was accomplished on-schedule, saved the client money from the original bid price through effective use of design modifications and construction techniques, and a treatment plant that has met Federal and State effluent discharge guidelines and continues to meet or exceed performance expectations.

Though site-specific problems dictate the type and extent of any hazardous waste treatment, this project serves as an example of effective groundwater remediation, as well as efficient and effective project management.

Front Street
Flow Schematic



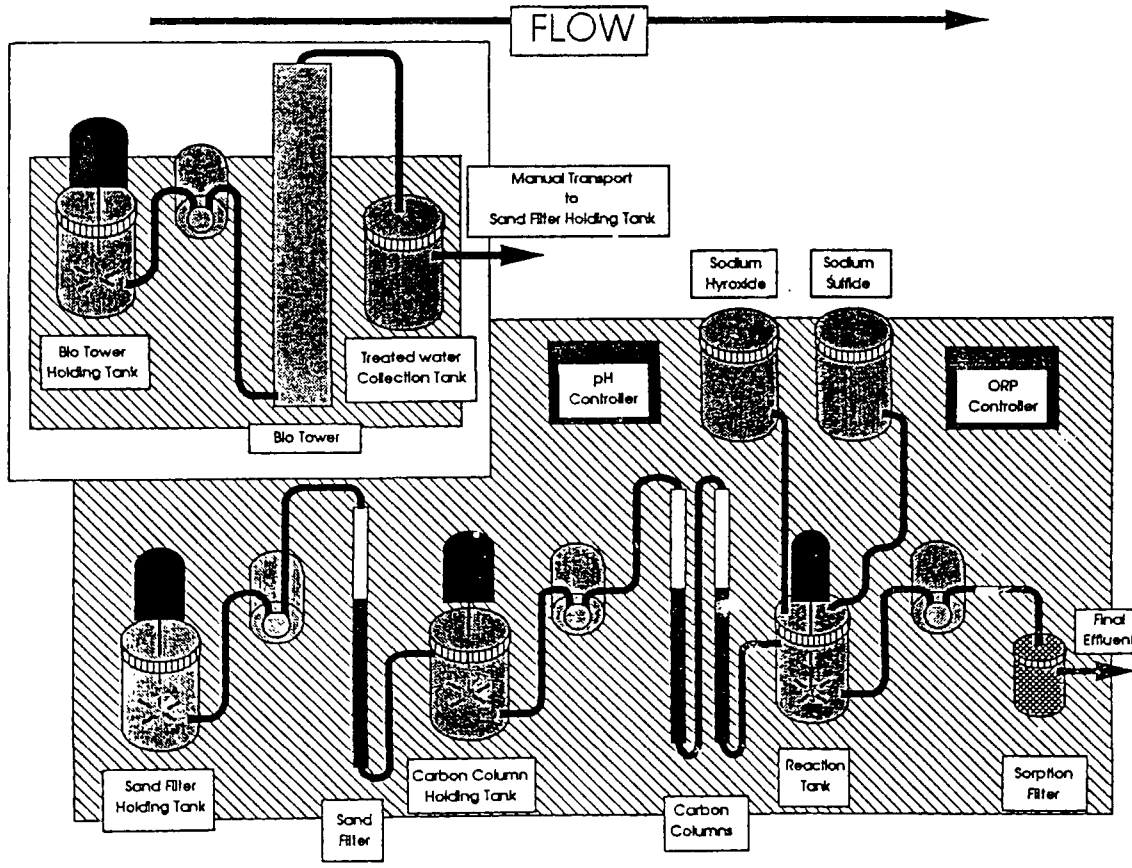


FIGURE 1

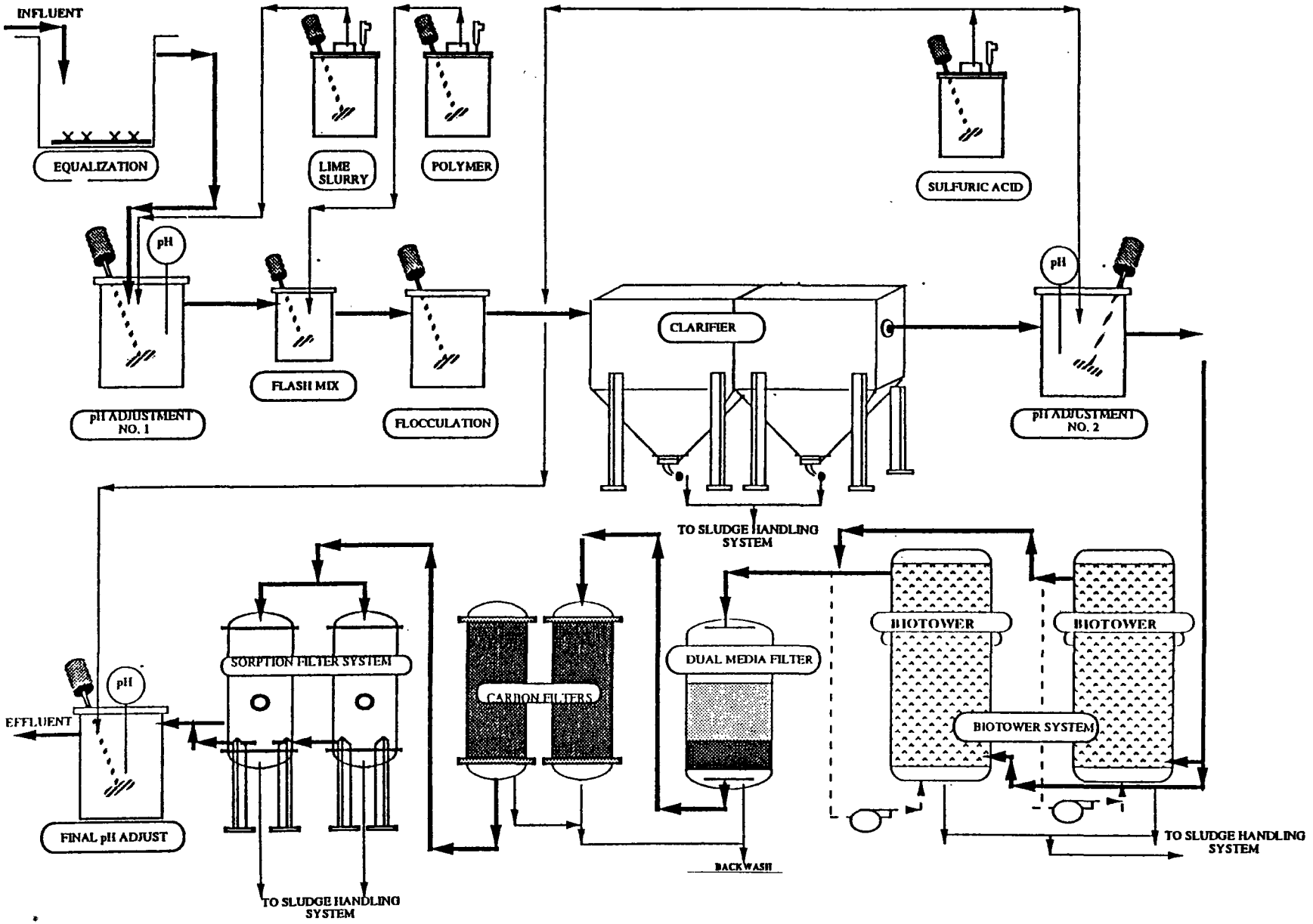

INFLUENT
EQUALIZATION
LIME SLURRY
POLYMER
SULFURIC ACID
pH
pH ADJUSTMENT NO. 1
FLASH MIX
FLOCCULATION
CLARIFIER
pH
pH ADJUSTMENT NO. 2
TO SLUDGE HANDLING SYSTEM
SORPTION FILTER SYSTEM
CARBON FILTERS
DUAL MEDIA FILTER
BIOTOWER
BIOTOWER
BIOTOWER SYSTEM
pH
EFFLUENT
FINAL pH ADJUST
TO SLUDGE HANDLING SYSTEM
BACKWASH
TO SLUDGE HANDLING SYSTEM

FIGURE 2

TREATMENT SYSTEM PERFORMANCE

TABLE NO. 1
HEAVY METALS

Parameter	Equalization Tank Influent	Equalization Tank Effluent	Metals Precipitation Effluent	Bio-Tower Effluent	Sand Filter Effluent	Carbon Filter Effluent	Sulfide System Effluent	Monthly Average Discharge Limit
Arsenic	90	70	<10	<10	<10	<10	<10	80
Beryllium	<2	<2	<2	<2	<2	<2	<2	20
Cadmium	30	30	<4	<4	<4	<4	<4	50
Calcium	449,000	460,000	400,000	418,000	410,000	400,000	237,000	none
Chromium	200	150	320	60	50	<6	10	200
Copper	260	220	20	<7	9	<7	<7	50
Iron	375,000	320,000	6,200	370	100	40	20	none
Lead	<5	<5	<5	<5	<5	<5	<5	50
Mercury	<.2	<.2	<.2	<.2	<.2	<.2	<.2	2
Nickel	2,200	1,900	350	370	370	170	80	2,380
Zinc	9,600	9,500	170	80	<50	<50	<50	1,480

FIGURE 3

Removal Efficiency of 1,2-Dichloroethene/4-Methyl-2-pentanone/Methylene Chloride

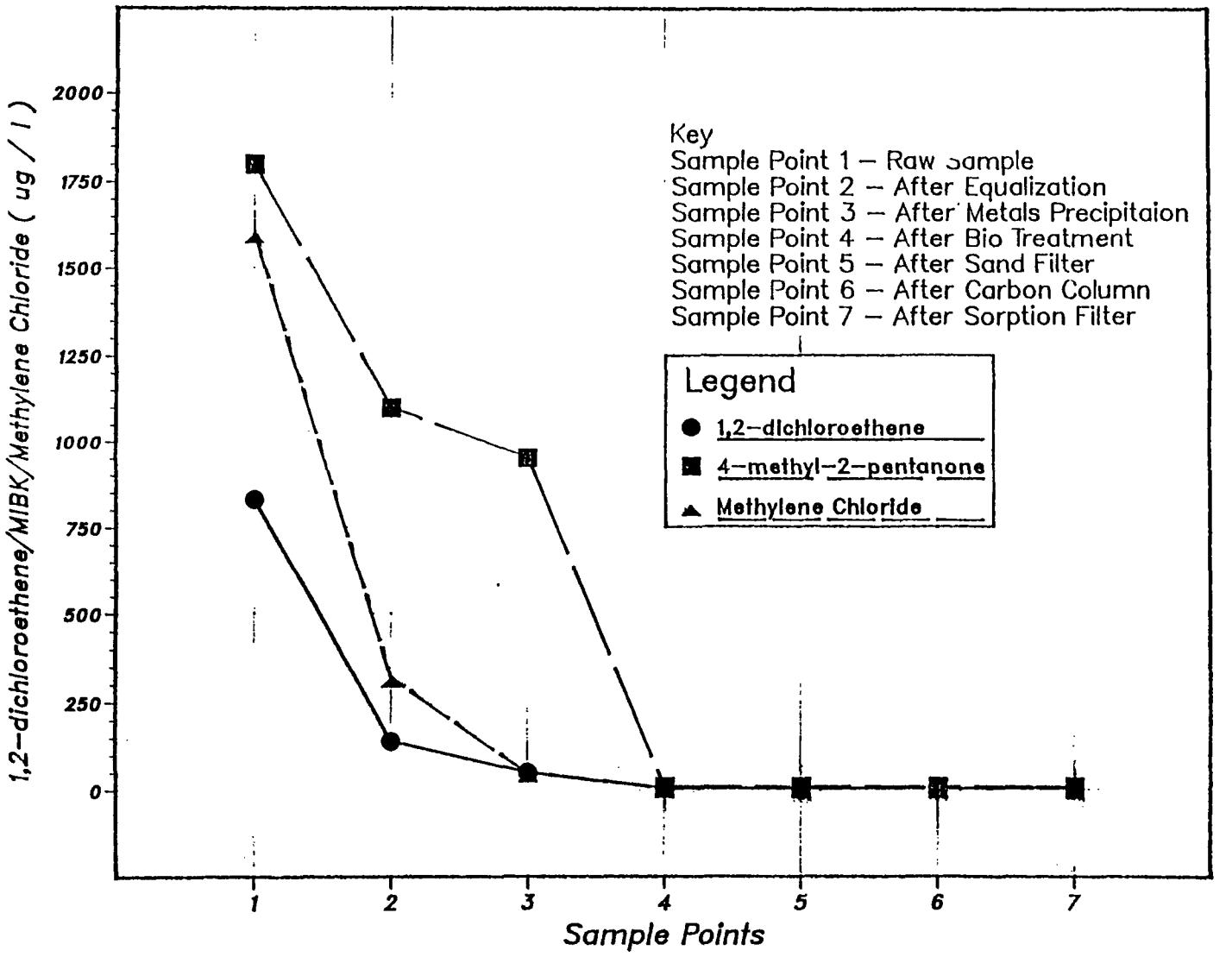
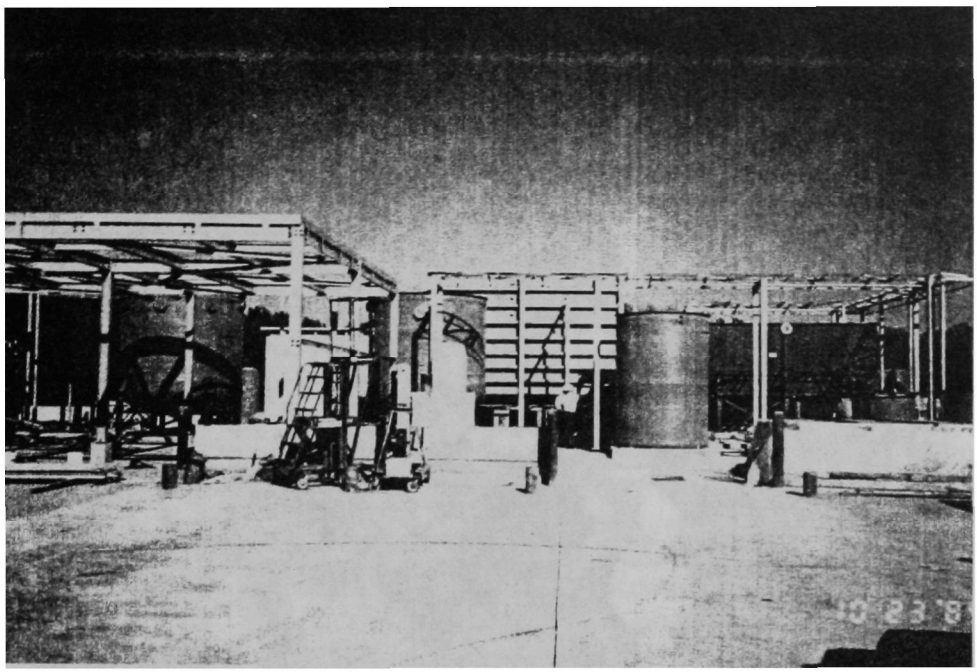


FIGURE 4



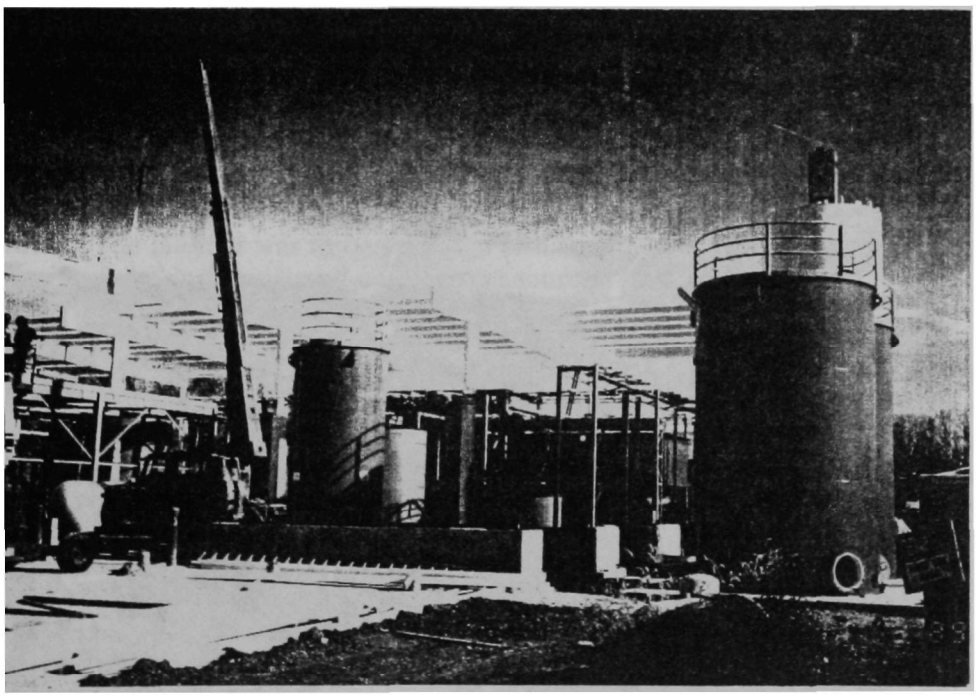
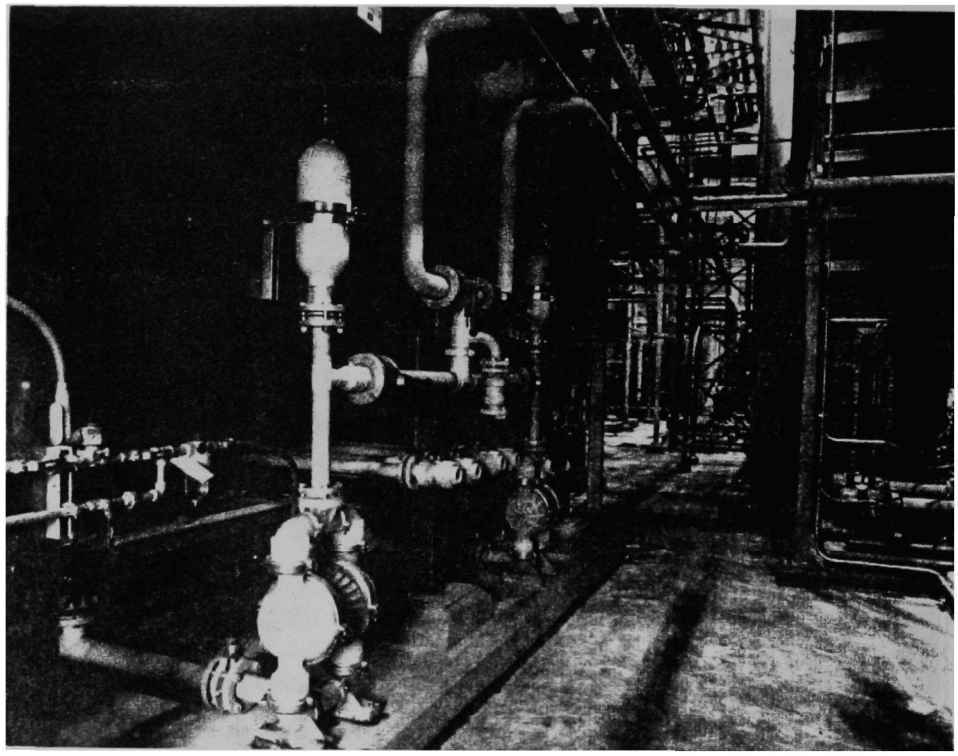


FIGURE 5



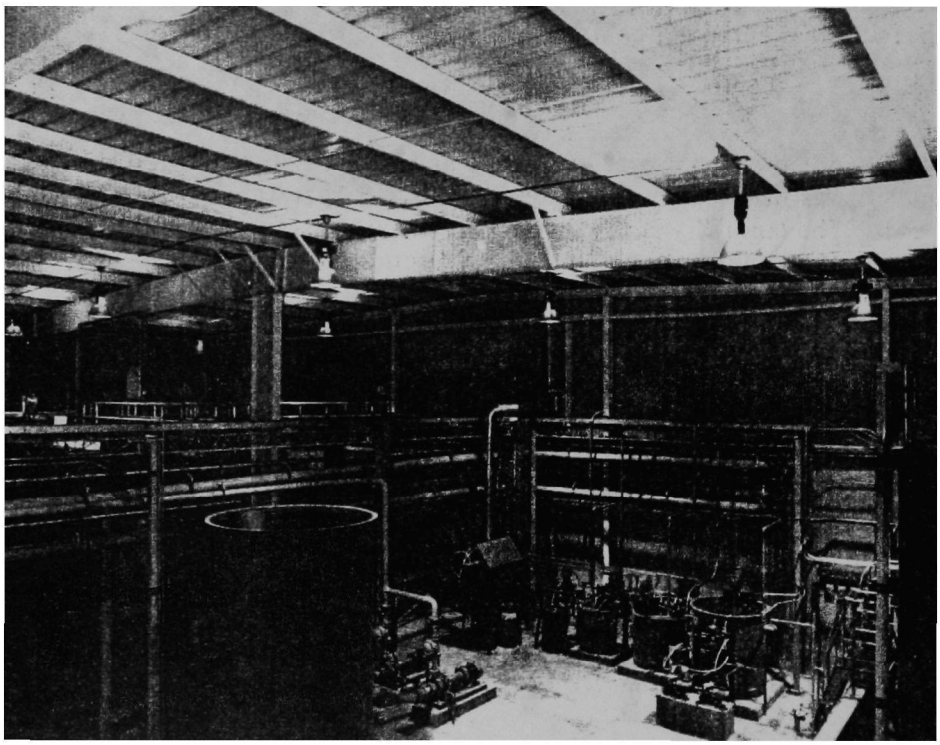


FIGURE 6

The Construction and Operation of the New Lyme Landfill Superfund Site Groundwater Treatment Facility

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(304) 529-5522

INTRODUCTION

The New Lyme Landfill Superfund Site is located in Ashtabula County, Ohio approximately 70 miles from Cleveland. Construction activities consisted of capping the existing 43-acre landfill and construction of a 100 GPM treatment facility to treat the leachate generated in the landfill. The water treatment plant flow is created by thirteen extraction wells located around the perimeter of the landfill cap. The treatment facility consists of the following unit processes: Equalization tank, pH Adjustment tank, Chemical Clarifiers, Neutralization tank, Rotating Biological Contactors, Biological Clarifier, Dual Media Sand/Anthracite filters, Granular Activated Carbon Units, Effluent Storage tank, Gravity Thickener for chemical and biological sludges, and Sludge Filter Press. The treatment facility is also equipped with a laboratory and computer equipment for analytical testing and a complete maintenance program.

This paper will provide an in depth look at this multi-faceted treatment facility and each unit process from a constructibility and operability standpoint. It will include the specific problems encountered during the construction and start-up of the facility and offer suggestions for their elimination at future site remediations that are equipped with a similar facility. Discussion will also include how the treatment facility is currently operating.

BACKGROUND

The New Lyme Landfill began operation in 1969 and was initially managed by two area farmers. In 1971, the landfill was licensed by the State of Ohio and operations were taken over by a licensed landfill operator. The landfill was to be operated as a trench-and-fill landfill with the majority of the wastes coming from industrial and commercial sources.

Operating violations were noted throughout the operation of the landfill and included water in the trenches, open dumping, uncontrolled access to the landfill, improper spreading and compaction of wastes, waste not being covered daily, inadequate equipment, no evidence of Ohio EPA approval for acceptance of certain industrial wastes, and excavation of trenches into the shale bedrock. On July 6, 1978, the Ashtabula County Health Department revoked the license to operate the landfill, and in early August 1978, the landfill was closed. The site was placed on the National Priority List (NPL) for Hazardous Waste Clean-ups in December 1982.

Data suggests that approximately 5,500 cubic yards of garbage, 8,000 cubic yards of commercial waste, and 14,000 cubic yards of industrial waste were disposed of at the landfill during each month of operation. As shown by the data collected on the landfill, a diversity of wastes were disposed of; therefore, the groundwater treatment facility had to be designed to treat a multitude of hazardous constituents.

DISCUSSION

The groundwater treatment facility is located on the north west side of the project area, approximately one hundred yards from the perimeter of the landfill. Access to outside tankage for deliveries has been accommodated by locating the building to the north of the extraction well access road. Consideration for expansion and/or additions to the processes is addressed in the design by equipment layout in relation to the building location on the site. A chain-link security fence, with gates, encompasses the facility with ample parking and service areas to the north, south and west of the facility. The treatment facility structure is a pre-fabricated building manufactured by Stan Buildings. The building dimensions are 80' x 142' 4" x 27'; it is anchored to a concrete slab. Although the dimensions of the building are rather large, the space had to be used quite efficiently. The process systems are housed in the building as well as an office, laboratory and complete shower and locker room facilities for the plant personnel. A mezzanine that spans 1/4 of the building is equipped with the mechanical components of the facility such as the HVAC system and air compressor. An electrical room located on the north west corner of the building houses the stand by generator unit and the motor control center for the automated process systems. The facility office houses a complete process monitoring panel and controls including process alarm and shutdown switches for the entire treatment system.

For simplicity, the discussion of the process systems will follow the same path as the contaminated groundwater through the plant and outline the construction of each process unit.

As stated in the introduction, the flow for the treatment facility is created by the thirteen extraction wells located around the perimeter of the landfill. From the extraction wells, the contaminated groundwater travels via a 4 inch force main through motor control valve and flow meter, to the Equalization Tank.

The Equalization Tank is located on the exterior south side of the treatment facility building. It is fabricated from plate steel and measures 22 ft. in height, 14 ft. in diameter and is set on a concrete base pad. It contains dilute leachate from the landfill. Equipment connected with the Equalization Tank is a coarse bubble and a fixed header aeration system for agitation of the tank contents. The exterior of the equalization tank is insulated with a flexible elastomeric covering to prevent freezing of the contents.

Actual installation of the system went rather well; however, two modifications did result. After insulation of the tank was complete, it was discovered that the ultra-violet rays emitted from the sun would break down the constituents of the insulation, making it brittle and ineffective. Therefore, the contract was modified to install a thin-gauge aluminum jacket over the insulation to protect it from the light. The jacket also protects the elastomeric insulation from the harsh winter climate experienced in Northern Ohio. The second modification came about at the time of initial testing, when it was discovered that the motors connected to the blowers used to agitate the leachate were over-heating. After some investigation and study, it was found that the blower units were undersized for the tank size. The contract was modified to increase the blower size to accommodate the Equalization Tank. Once the modifications were made, the aerated leachate discharges from the Equalization Tank via an overflow at the top of the tank and gravity flows to the pH Adjustment Tank.

The pH Adjustment Tank is located adjacent to the interior south wall of the treatment facility. The tank is fabricated from steel and measures 6 ft. in height, 5 ft. 6 in. in diameter and is set on structural steel platform legs. It contains dilute leachate and sodium hydroxide (NaOH). Equipment associated with the pH Adjustment Tank includes a small mixer and a pH metering probe located in the discharge baffle. To feed the pH Adjustment Tank, a 50% solution of NaOH is stored in the

caustic storage tank. The caustic is introduced into the pH Adjustment Tank by caustic feed pumps and controlled by a pH probe on the discharge side of the baffle. The caustic storage tank is fabricated of steel and has a capacity of 3500 gallons.

A few months into the operation of the facility, a problem occurred with the pH adjustment process. The weather got colder and the groundwater temperature decreased to the point that it was below the freezing temperature of the caustic solution. To alleviate the problems associated with the introduction of caustic solution into the pH Adjustment Tank it was necessary to dilute the 50% solution. To accomplish the dilution, it was necessary to add a 150-gallon, steel mix tank within the retaining wall of the caustic storage tank ahead of the caustic feed pumps. The mix tank process will only be used until the current supply of 50% solution is exhausted, after which a weaker solution of caustic will be supplied. Another problem that makes the facility unable to operate at the 100-gpm design flow rate is clogging of the 4-inch influent line between the Equalization Tank and the pH Adjustment Tank; therefore, the contract will be modified to provide an in-line static mixer, as well as a direct caustic injector system, and pH probe for the pH adjustment process. A switch will also be added to utilize the existing pH adjustment process if needed. Flow from the pH Adjustment Tank discharges by gravity to the Settling Tank where the precipitated metals are separated.

The Settling Tank is located just right of the pH Adjustment Tank, adjacent to the interior south wall of the treatment facility. The tank walls are fabricated from steel tied into a bowl-like concrete base to accommodate the sludge collection equipment. The Settling Tank measures 30 ft. in diameter and approximately 10 ft. in height. Equipment for the circular sludge collector in the Settling Tank includes torque tube and scraper arms, drive mechanism, feed influent flume, chemical mixing and high rate internal recirculation components, slurry recycle for solids contact and upflow clarification. A structural steel bridge spans the tank diameter and supports the entire collector mechanism and also serves as an operator access deck.

Due to the immense size of the Settling Tank and the fact that the concrete pad was founded on #57 aggregate, the contractor proposed the use of a footing to prevent settlement. The contractor felt that the #57 aggregate would not hold its shape as a form for concrete; therefore, a substitution of #307 aggregate was suggested. The contract was modified to incorporate both suggestions in the tank foundation as well as in the foundation for the Biological Clarifier unit. The clarified liquid in the Settling Tank flows by gravity to the Neutralization Tank where it's pH is lowered to 7.0 and the solids are pumped to the Gravity Thickener.

The Neutralization Tank is located just right of the Settling Tank, adjacent to the south wall of the treatment facility. The tank is fabricated from steel and has a capacity of 1,000 gallons. The tank is set on a 10 ft. high structural steel platform and contains dilute leachate mixed with H_2SO_4. Process equipment connected with the Neutralization Tank includes a small mixer and pH metering probe located in the discharge baffle. A 93% solution of H_2SO_4 is stored in the acid storage tank adjacent to the exterior south wall of the treatment facility. Introduction of the sulfuric acid solution into the neutralization tank is accomplished by utilizing the acid feed pumps. The acid storage tank is fabricated of steel and has a capacity of 3,500 gallons. A wall is constructed around the acid storage tank to contain spills.

When the contractor was acquiring the components of the acid and caustic storage tanks, the manufacturer named in the contract specifications as the supplier of the level float switches advised the contractor that their product was not suitable for caustic and sulfuric service. The contract was modified to utilize a level probe constructed of stainless steel attached to teflon-coated wire which terminates at the polycarbonate housing and PVC flange at the top of the respective acid storage and caustic storage tanks.

During final phases of work on the treatment plant, it was determined that a safety hazard existed due to the location of the fill lines for both caustic and sulfuric acid storage tanks. After filling of these tanks, a reverse head pressure would be in the tanks when the hose was released from the supply truck. This would create a potential for a chemical spill at either tank. For safety considerations, the contract was modified to relocate the filling lines to the top of the acid storage and caustic storage tanks.

Flow from the Neutralization Tank enters the RBC splitter box and discharges over a straight-edge weir to the Rotating Biological Contactors (RBCs). The flow can be routed to one, two, or three RBC shafts, depending on the wastewater characteristics. The RBC units are located just right of the Neutralization Tank, adjacent to the interior south wall of the treatment facility. The RBC units are comprised of two different materials. The bottom, or tank portion of each unit, is fabricated from plate steel. The covers on the RBC units are fiberglass- reinforced plastic. Each section of the cover is a continuous arch with no bolting required between sections. End panels are easily removable for equipment access. Sections join each other and the end panel by overlapping corrugations.

Components and equipment associated with the RBC units are as follows: media, consisting of high-density linear polyethylene material; central steel shaft to support the rotating media; a structural support system to prevent lateral and radial movement of the media; a drive system including motor speed reducer, sole plate, base bars, chain casing and roller chain; and supplemental air piping. The units are also equipped with a structural operating platform for ease of maintenance.

Two positive displacement blowers are located in the blower room of the treatment facility due to noise considerations; they provide the air needed to stop excess growth on the shaft as well as provide air for aerobic growth. Each unit delivers a maximum of 375 scfm, a total of 750 scfm. The contract phrasing indicated that each blower was to deliver 750 scfm, which was incorrect; therefore, the contract was modified to state a total of 750 scfm was to be provided. The RBC effluent flows by gravity to the RBC Effluent Tank where the leachate is pumped via variable speed pumps, through the RBC Effluent tank, to the Biological Clarifier.

This RBC Effluent tank is located adjacent to the interior east wall of the treatment facility. It is fabricated from steel and has a capacity of 5,000 gallons. The tank contains treated leachate from the RBC units and acts as a reservoir from which the treated leachate is pumped to the Biological Clarifier.

The Biological Clarifier is located adjacent to the interior north wall of the facility. The tank walls are fabricated from steel tied into a bowl-like concrete base to accommodate scraper equipment. The Biological Clarifier measures 22 ft. in diameter and 10 ft. in height. Equipment for the circular sludge collector in the Biological Clarifier includes torque tube and scraper arms, drive mechanism, and influent feed well. A structural steel bridge spans the tank diameter and supports the entire collector mechanism and also serves as an operator access deck.

The biological solids produced from the RBC's and settled in the Biological Clarifier are pumped to the Gravity Thickener by two air-operated diaphragm pumps. The clarified wastewater flows by gravity to the sand filter splitter box through a V-notch weir. The feed is equally divided between the two sand filters, operating in parallel.

The Sand Filter is located adjacent to the interior north wall, just left of the Biological Clarifier. The Sand Filter Tank is a steel gravity multiple cell unit that measures 6 ft. wide and 8 ft. long and 11 ft. in height. It is constructed of 1/4-inch plate steel and reinforced to withstand the hydrostatic pressure encountered. The filter also has an underdrain system to reduce the water velocity, discharging the water horizontally without impeding the flow, thereby preventing channeling of the

bed. A filter trough is provided in each filter cell for collection of the backwash water. Inlet and wash water collection gullets receive and apply inlet water to the filter and collect wash water from the wash troughs. Four 16-inch layer gravel beds serve as the supporting beds for the filter. The filter media is a uniform grade anthracite. Equipment used for backwash of the filter include a positive displacement blower for air scour to the media and a pump for simultaneous air water backwash. A level float in each cell will automatically initiate sand filter backwash with treated water from the effluent tank. The backwash water from the filters is discharged to the Recycle Tank. Backwash can be controlled both automatically or manually with pneumatically operated valves. Backwash is accomplished with treated water from the effluent tank and discharges to sump for recycle to the RBC blowers. The Sand Filter is also equipped with an operating platform and walkway. The Sand Filter effluent flows by gravity to the filter effluent tank.

The Sand Filter Effluent Tank is located adjacent to the sand filters. It is fabricated from steel and has a capacity of 1000 gallons. The tank contains treated leachate from the sand filters and serves as a reservoir from which the leachate is pumped to the Granular Activated Carbon Units by variable speed pumps.

The Granular Activated Carbon (GAC) system consists of two column adsorbtors that may work in series or parallel. The units are located adjacent to the interior north wall, just left of the sand filtration system. Calgon Corporation was the supplier of the GAC system and was totally responsible for the design, fabrication, installation and start-up of all unit components. The total system contains 40,000 pounds of granular activated carbon. Carbon replacement is performed using a truck and fill pipe. Spent carbon is discharged directly to the truck by pressurizing the column with air from the compressed-air system. New carbon is added by pressuring the truck with water to force the new carbon into the columns. Carbon offloading is accomplished by utilizing the end suction pump and associated piping that is connected to the Effluent Storage Tank. Water may also be drained to the Recycle Tank from the GAC for reprocessing.

The Recycle Tank is located behind the sand filters, adjacent to the north wall of the facility. It is fabricated from steel and has a capacity of 1500 gallons. The Recycle Tank accepts backwash water from the sand filters, drainage from the GAC's, filtrate from the filter press, and supernate from the Gravity Thickener. The Recycle Tank contains a sump pump which pumps the water to the RBC splitter box or the Equalization Tank for reprocessing.

Flow from the GAC units is collected in the Effluent Tank. The plate steel effluent tank has a capacity of 12,000 gallons and is sized to allow its water to be used for sand filter backwashing, area hose bibs, lime slurry mixing, pump seal water, filter cloth wash and carbon offloading. In addition, two centrifugal recirculation pumps provide the capability to pump effluent water back into the system. Recirculation can occur from the Effluent Tank to the Equalization Tank, RBC splitter box, or Sand Filter Effluent Tank.

Discharge out of the Effluent Tank is over a straight edge weir, after which the flow is sampled and measured prior to discharging to Lebonan Creek.

The Gravity Thickener receives sludge from the Biological Clarifier and the Settling Tank. The Gravity Thickener Tank components include steel tank walls, bottom and supports; torque tube, drive mechanism, influent diffusion well, collector arms, access bridge, and control equipment. The tank measures 10 ft. in diameter and 8 ft. in height. It was determined that a ladder assembly should also be furnished to provide access to the gravity thickener and the contract was modified to incorporate this change. From the Gravity Thickener, the sludge is pumped to the Flash Mix Tank where lime is added.

The 50-gallon Flash Mix Tank is fabricated from polypropylene and is used for a quick, high energy contact of lime and sludge. The tank is located just left of the Gravity Thickener. The lime is added to the sludge as a conditioning agent since conditioned sludge dewaters more readily and creates a cake that is less likely to stick to the filter press cloth. The lime is stored in a lime storage silo. It is here that the lime slurry is mixed and pumped to the Flash Mix Tank. The Lime Slurry System is a self- contained unit located on the exterior of the building adjacent to the Equalization Tank. The system contains a lime storage silo, complete with bulk unloading facilities. Located in the bottom portion of the silo is the lime slurry mix tank, lime slurry feed pumps, and associated system controls. The silo is equipped with a dust-collection system which may be activated by the operator prior to bulk lime unloading. The mixture flows out of the Flash Mix Tank and into the Sludge Conditioning Tank.

The Conditioning Tank is where the sludge and lime are blended. The tank is fabricated from polypropylene and has a capacity of 400 gallons. A slow speed mixer is used to blend the sludge and lime, then the sludge is pumped to the filter press for dewatering.

The filter press is a plate-and-frame press capable of dewatering 13.5 cu. ft. of conditioned sludge per cycle. The daily operation is set up around two cycles per day with each cycle lasting 2.5 hours from press close to cake discharge. Cycle time can be adjusted by plant personnel. A modification was made to the filter press system. In order to properly meet the demand of the filter press unit, the manufacturer recommended that the two-inch outline for the filter press be changed to a six-inch line to facilitate the dewatering process.

The filter press is located on the mezzanine to allow for direct cake discharge. The cake will be transported by sludge truck to a RCRA licensed landfill.

Two air compressors are located on the mezzanine. These compressors supply high- and low-pressure air for all pneumatic controls, as well as air-operated pumps. The air compressor system also incorporates a 120-gallon air receiver, two free-standing type air-cooled after coolers, intake filter and silencer, refrigerated air dryers for moisture removal, and coalescing filter.

The layout of the process systems in the building is such that a truck or small crane can access all process units for maintenance. A one-ton monorail crane is provided in the facility for O&M purposes. Vehicle access is accomplished through the overhead door that also serves as access to the filter press for removal of the cake. The installation of the overhead door required the contractor to remove the metal siding around the door after the building was erected, install additional support steel, and replace the siding. The work involved in the installation of the door was determined to be above the requirements of the contract and the contract was modified to compensate the contractor for this additional work.

The laboratory is supplied with equipment for anticipated routine process monitoring and control tests, as well as anticipated permit parameters for conventional pollutants. Space has also been provided in the laboratory for adding a gas chromatograph or atomic absorption apparatus. This more sophisticated equipment would allow for on-site analysis of priority pollutants. It was determined to be necessary to provide capabilities for the on-site lab to perform BOD testing; therefore, the contract was modified to compensate the contractor for furnishing necessary equipment and material to perform such testing.

Numerous other modifications to the treatment facility have been made to ensure proper operation, accommodate maintainability, and enhance the safety features. A discussion of these modifications follows.

An additional valve was added to the line for the existing sand filter, in order for this process to be segregated from the remainder of the plant for subsequent O&M considerations. The water supply system for servicing the emergency eye wash in the lime storage silo was changed to potable water as opposed to plant effluent in order to prevent the use of treated water as an eye wash. An air supply header to the RBC effluent tank was extended off of the RBC feed line to prevent the deposition of solids in the tank during solids transfer operations from the RBC's. A small sump on the exterior of the treatment plant was installed to capture carbon fines contained in the overflow from the GAC units to prevent the inclusion of fines in the treatment plant sump. A "ship's ladder" to the pH Adjustment Tank was installed for access to the tank to allow for pH probe adjustment and mixer maintenance. A feed system from the effluent tank to the filter press line was installed to allow purging of the feed line after every filter press application. Funnel connections for all sampling ports that discharge to a floor drain were provided to prevent the discharge of water over the treatment plant floor. A special corrosion protection for the high pH environment in the lime mixing tank was applied. Connections for the portable samplers were provided. A protective cage was installed around the phosphoric acid barrel for safety considerations. A surge arrestor was installed for the treatment plant. Wiring was changed as necessary to provide spare circuits. Two pending modifications provide a trailer and pump for cleaning out sumps around the perimeter of the landfill, and conduct sampling of each extraction well to provide a database on the leachate constituents that each well is producing. A problem with phase loss or "brown out" has occurred since the facility has been in operation. An exhaust fan motor was burned out due to this condition and the process equipment has to be monitored very closely. The contract is being modified to install Brown Out protection equipment on the main disconnect on the Motor Control Center to protect the treatment facility from power phase loss.

The groundwater treatment facility has been on-line in some capacity for approximately six months. Due to operation of the facility being in its infancy, there are still minor problems with the operation that are being ironed out by some of the pending modifications noted in the previous discussion. According to the operator of the facility, Dave Thompson of Sevenson Environmental Services, Inc., the problems being encountered are in the primary treatment processes, e.g., from the Equalization Tank to the RBC's. The line between the Equalization Tank and the pH Adjustment Tank is clogging with residue and the facility is unable to operate at the design flow of 100 gpm. He believes sediment and high concentrations of calcium, iron and magnesium are collecting on the butterfly valve components in the line and restricting the flow. He recommends that future designs have full port ball valves incorporated into the primary process lines to eliminate any restrictions in flow.

In addition, in future contracts consideration should be given to the use of plastics where applicable in order to reduce costs incurred by steel fabrication and process piping systems. In this contract, all of the process tanks in the treatment facility were fabricated from steel with the exception of the Flash Mix Tank and Conditioning Tank. At the contractor's request, schedule 80 PVC piping was approved in lieu of the steel pipe specified in the contract for the following process lines: Raw Wastewater, Settling Tank Influent, Settling Tank Effluent, Biological Clarifier Influent, Filter Influent, Filter Effluent, Carbon Effluent, Primary Effluent, Filtrate and Recycle lines.

As outlined in the construction contract, upon completion of construction of the extraction well system and groundwater treatment facility, the contractor had the responsibility to start-up the facility, and then to operate the facility for a period of one year. After the one-year operation period the facility will be relinquished to the State of Ohio. Operator staffing of the facility during the obligatory period is a minimum of eight hours each day by a staff of two people, one of which must hold a current Class 2 Wastewater Treatment Plant Operator's license issued by the State of Ohio. During unmanned hours at the plant, the operator must be on call and reachable for emergency occurrences. The treatment facility is equipped with an automatic dialer system that will call pre-programmed telephone numbers if an equipment breakdown occurs. The Contractor was also required

to retain the services of a Class 3 Wastewater Treatment Plant Operator licensed by the state of Ohio, if needed.

A wastewater treatment specialist, retained by the contractor, is responsible for preparing a Systems Operation Manual and preparing a formalized training program. The manual includes system and process descriptions, locations, start-up procedures, normal operation procedures, emergency procedures, shutdown procedures, instrumentation and electrical control systems, and scheduled and unscheduled maintenance procedures. The Contractor was also required to provide computer equipment and computer programs for record keeping and maintenance. Equipment at the site consists of an Epson Equity II computer, Okidata printer, Macola Operator 10 maintenance software, and Lotus 1-2-3 software. The formalized training program for the State of Ohio personnel will include user start-up, operational training and instruction sessions for at least 10 working days near the end of the Contractor one year operational requirement.

The one-year period of operation required by the contract has been an immense help in ironing out the problems encountered when starting up and operating a facility of this magnitude. With the job still under contract, an avenue was available to modify the system, if necessary, to make a quality end product for the user -- in this case Ohio EPA. The one-year operation requirement should be placed in any contract with such complicated systems, in order to address modifications such as the ones discussed throughout this paper.

CONCLUSION

The construction of such a complex facility to treat the diversified wastes found in the landfill was not going to be perfect when all the switches were turned on and the water began to flow. As noted in the discussion of the facility, many modifications were made to insure proper operation, accommodate maintainability, and enhance safety of the treatment facility. Many of these modifications were the result of problems encountered during the start-up or initial operation of the facility. Because of an innovative contracting procedure that has instilled the responsibility of start-up and one-year operation of the facility in the construction contractor, we were able to use the construction contract to make modifications and provide a better end product to the customer.

The total project construction cost for the remediation of New Lyme Superfund Site is approximately 15.2 million dollars. Of the total construction contract amount, 2.8 million dollars was spent on the groundwater treatment facility, which is the corner stone of the remediation. Comparing these figures to the cost of removing the wastes from the landfill and treating the contaminated soil and water off-site, you can see the financial viability of this method of remediation.

The tasks of constructing and operating this sophisticated facility are secondary to the overall benefits gained. Treatment facilities of this caliber will make a monumental difference in site remediation where a diversity of contaminated leachate is present and the possibilities for site-adaption on other projects is endless.

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Dave Thompson, Sevenson Environmental Services, Class 2 Wastewater Operator at New Lyme Superfund Site.

Margaret Wren Wilson, Resident Engineer, New Lyme Superfund Site.

Arsenic Removal at the Lidgerwood Water Treatment Plant

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INTRODUCTION

The objective of this paper is to present an evaluation of the operating problems experienced by the Lidgerwood, North Dakota Water Treatment Plant (LWTP), the causes of the plant's poor performance, and the resulting modification design . The original LWTP was constructed in 1985 to remove arsenic, with secondary removal of iron and manganese from the City of Lidgerwood's water supply. The original plant was plagued with operational problems and, consequently, often produced water of an unacceptable quality. As a result, in 1986, a Record of Decision was signed to correct the plant's problems. In 1988 the Bureau of Reclamation (Reclamation) was asked to design, specify, and provide contract management services for the LWTP modification.

BACKGROUND

LWTP is located on the North Dakota Arsenic Trioxide Site, which is an Environmental Protection Agency (EPA) Superfund site placed on the National Priorities List. Routine sampling in 1979 found that levels of arsenic in the Lidgerwood water supply exceeded the Maximum Contaminant Level (MCL). The contamination of the groundwater supply is due to natural arsenic deposits and to widespread use of arsenic-based pesticides for grasshopper infestations in the 1930's.

Lidgerwood is located in the southeast corner of North Dakota. It has a population of approximately 970. The LWTP was built in 1985 under the provisions of the Safe Drinking Water Act. The facility was rated at 252 gal/min and was designed to:

- oxidize ferrous iron and manganese ions,
- co-precipitate arsenic,
- filter out suspended material,
- disinfect with chlorine.

Approximately 6 months after the plant started up, operational difficulties were observed. The plant was reportedly offline frequently. When this occurred, untreated water was delivered to the city distribution system. Also, treated water from the plant periodically failed to meet the primary arsenic standards of 0.05 mg/L and secondary drinking water limitations for iron of 0.30 mg/L, and manganese of 0.05 mg/L. The treated water was also periodically "pink" or "brown" due to poor adjustment of potassium permanganate demands. As a result of these problems, an EPA Remedial Investigation/Feasibility Study for the Arsenic Trioxide Site was completed and a Record of Decision to modify the plant was signed in September, 1986.

Representatives from the city, state, EPA, the city's consulting engineers, and Reclamation met in October, 1988 to review the LWTP's operating history. This group identified some of the probable factors effecting the plant's poor performance. A plan of action was also assembled. Subsequently, Reclamation engineers further evaluated LWTP's operating records and identified additional factors

which were partially responsible for the plant's poor performance. At that time, Reclamation proposed remedies to modify the plant. In December, 1988, Reclamation was requested to design, specify, and provide contract management services for the LWTP modification. Due to the imminent health risks associated with the poor plant performance, an accelerated design and construction schedule was established whereby all work would be completed by November, 1989, the end of the 1989 construction season.

DISCUSSION

Reclamation evaluated LWTP's problems by breaking the plant into three areas of attention: the chemical process, the equipment, and the plant operation. The predominant problems which were identified are listed below.

- poor mixing of chemicals added after aerator
- manual operation of filter backwashing sequence
- use of an inappropriate pump for filter backwash
- marginal detention time in reactor (20 minutes)
- inadequate in-plant storage volume for treated water
- variation of manganese content in raw water and the absence of instrumentation needed for determining potassium permanganate demand for treating manganese
- inadequate control over influent flow rates
- awkward handling of sludge in the backwash recovery basin
- crowded facility

In order to resolve the observed problems, recommendations were made regarding the process, the equipment, and operation. These recommendations were based on results from bench-scale laboratory verification testing. The testing was conducted concurrent to the design as a means of fast-tracking the project. The concurrent testing proved to greatly accelerate the design process by providing timely input of design data as the process proceeded. The bench-scale testing, entitled Verification of Process Testing, was divided into a number of sub-tasks. Briefly, these sub-tasks included investigating the following topics:

- evaluation of reaction times for removal of manganese, iron, and arsenic
- effect of coagulant addition and freshly activated sand on manganese, iron, and arsenic removal
- effect of temperature, seeding, addition of ferrous chloride and chlorination on manganese, iron, and arsenic removal
- evaluation of settling rates of oxidation products and aged sludge
- evaluation of the possibility of re-solution of manganese, iron, and arsenic
- analysis of fresh and used activated sand coating, and scale coating on flow nozzles

The Verification of Process Testing indicated that residence time in the detention tanks should be increased to 60-90 minutes in order to produce large, well filterable flocs. A flocculent aid, such as the non-ionic type used in this study, was found to enhance flocculation and is particularly important in manganese removal. In addition, the findings from the bench-scale testing indicated that re-solution of the contaminants over a 12-week period does not occur in any significant amount and should therefore not be a problem in the backwash basin.

Based on the aforementioned observations and in concordance with the results from the bench-scale testing, Reclamation proposed the following recommendations to modify LWTP in the areas of the chemical process, the equipment, and operation. A process flow diagram, Figure 1, delineates many of these recommended changes.

Recommendations for the chemical process include:

- provide adequate time to allow the iron, manganese, and arsenic precipitates to agglomerate in the detention tank
- continue to use a non-ionic polymer as a flocculent aid
- continue to use potassium permanganate as the oxidant

Recommendations for changes in equipment include:

- convert the compartment below the aerator into a mixing tank
- automate the manually controlled backwash sequence and add a filter-to-waste cycle
- provide an additional 20,000 gallons of storage for clearwell water
- construct a 15'x15'x10' detention tank to provide 80 minutes of detention time
- purchase a spectrophotometer and color monitor to determine more accurately the potassium permanganate demand and provide a means to alarm when there is a color breakthrough
- install a flow and pressure regulating valve in the influent line
- provide access handways near the underdrain at each filter cell
- increase the building size to twice its original to accommodate the retrofitted equipment

Recommendations for changes in plant operation include:

- revise the filtration operation throughout the day and backwash at the end of the day, as required. Add a filter-to-waste cycle
- reactivate the recycle of the supernatant from the backwash water recovery basin
- allow the sludge to remain in the bottom of the basin in the inactive zone during winter operation; during the remaining part of the year pump the sludge to the sludge filter bed to separate the precipitates
- train operators to operate the plant as designed and as modified

Reclamation was requested to design the LWTP modification in December, 1988. The resulting schedule, quite short due to the imminent health threat and the short construction season, is shown below:

Concept	2/1/89
Design Complete	5/1/89
Bench-scale Tests	2/1/89 - 5/1/89
Bid Opening	7/13/89
Award	7/19/89
Construction Complete	1/30/90

The plant has been operating successfully since modification and operator training. The treated water has consistently met drinking water MCLs since modification. Results from the North Dakota State Department of Health and Consolidated Laboratories have indicated that the arsenic levels in the treated water have been reduced from 0.134 mg/L to 0.019 mg/L. In addition, analytical results for the arsenic sludge have shown concentrations of 0.056 mg/L, which is well below the hazardous waste category of 5.0 mg/L.

CONCLUSIONS

Due to sporadic performance at the LWTP and the resulting production of water of an unacceptable quality for human consumption, EPA requested Reclamation to design, specify, and provide contract management services for the LWTP modification. This request was made in December, 1988. Reclamation issued the specifications and awarded the construction contract by July, 1989. The field cost for the plant modification was $316,000. The timely response to remediating LWTP's problems was made possible through cooperation and a team approach between EPA and Reclamation, and concurrent bench-scale verification testing. Construction was completed on the LWTP modification in January, 1990. Water quality results from the time of modification to present have indicated that the treated water is in compliance with the drinking water standards.

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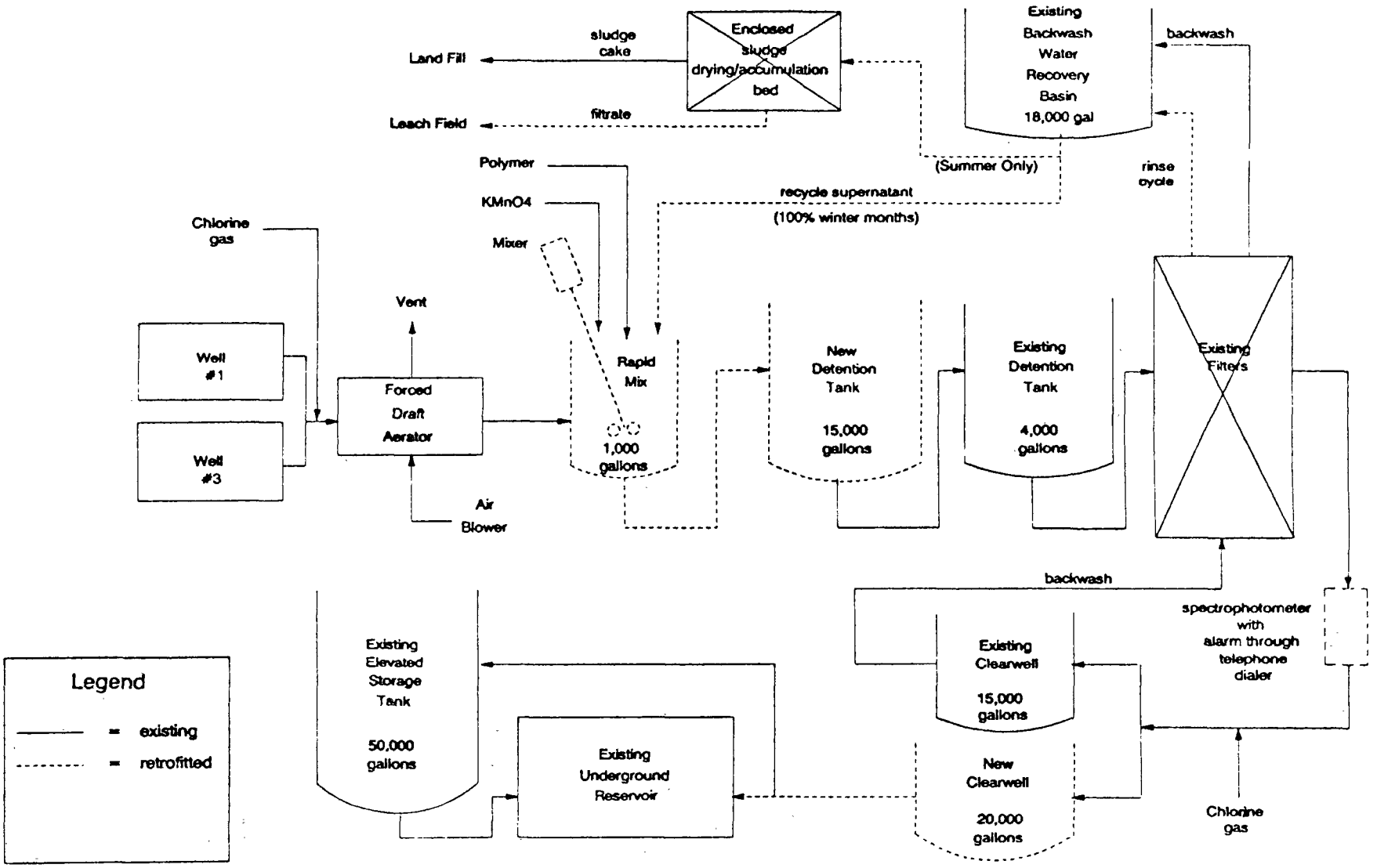
FIGURE I – LIDGERWOOD WATER TREATMENT PLANT

Process Flow Diagram



SUCCESSFUL PROGRAM MANAGEMENT FOR REMEDIAL DESIGN/REMEDIAL ACTION

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INTRODUCTION

The remedial design/remedial action program for the CERLCA site located at Seymour, IN will be successfully completed approximately two years ahead of the schedule in the Consent Decree. The construction work has been completed without a recordable injury. In addition, the work has progressed without a health/safety problem to the public. Approaches to the project which made this result possible included extensive up front planning, team building among all participants. PRP representatives, contractors and the agencies, strong field safety approach and extensive public relations programs. This paper discusses the scope of the work, the approaches to managing the work, and the problems encountered as a result of data developed during design, the accomplishments of the project as well as some lessons learned in attempting to manage projects under CERCLA.

BACKGROUND

The Seymour Recycling Center SRC Site is located approximately 2 miles southwest of the City of Seymour, Indiana. From approximately 1970 until 1980, this 14-acre site was operated as a processing center for waste chemicals. The activities at the site included chemical fuel projection, reclamation, incineration and drum crushing.

Over the period of operation of the SRC site, the owners lost control of the facility. As of early 1980, over 50,000 drums, 100 bulk storage tanks and numerous tank trucks were located at the SRC site. A significant number of the containers were in weakened or damaged condition. Hazardous substances and other substances had leaked from the containers onto the ground resulting in soil contamination, vapor emissions, fires and odor

problems.

Beginning in late 1982, a major surface cleanup action was performed by Chemical Waste Management, Inc. The cleanup was monitored by the USEPA and the Indiana State Board of Health. All wastes at the surface were removed including the drums, the bulk storage tanks, and contaminated soil from designated areas down to a depth of approximately 1 ft. A 1 ft clay cap was placed over approximately 75% of the site.

The Remedial Investigation (RI) began at the site in August 1983 and continued through November 1985. The RI document was published in May 1986. The RI concluded that the soil under the site was contaminated, a shallow aquifer under and adjacent to the site was contaminated and a deep aquifer under and adjacent to the site possibly was contaminated. The Feasibility Study (FS) document was published in August 1986.

The approximately 300 Potentially Responsible Parties (PRPs) involved in this site can be divided into two groups. One group was involved in a consent decree focusing on the surface cleanup. Those PRPs who were a party to this consent decree were absolved of any responsibility for the subsurface cleanup. A consent decree dealing with the subsurface cleanup was entered in the Federal District Court in December 1988. The 109 PRPs who were party to the subsurface consent decree agreed to manage the remedial program. Monsanto Company, the largest financial contributor to the remedial program was asked and agreed to be the Trustee for the Trust established to implement the provisions of the consent decree. During the course of the negotiations of the 1988 consent decree, an Agreed Order was executed for the installation of a temporary pump and treatment system. The system was to be utilized to remove water from the contaminated shallow aquifer and to treat the water in a test pretreatment plant. Data from the test were to be utilized in the design of a permanent pretreatment plant.

PROJECT SCOPE

The remedial action program for SRC can be broken down as follows:

PROBLEM	SOLUTION
• Contaminated shallow aquifer	• Plume stabilization project • Long-term operation & maintenance • Ground-water monitoring
• Potentially contaminated deep aquifer.	• Ground-water monitoring • Potential for pumping restriction

	from the aquifer
	• Potential for pump & treat
• Contaminated soil	• Building demolition
	• Vapor extraction system
	• Off-site soil excavation
	• Multi-media cap
	• Roads, fences, drainage
	• Enhanced bioremediation
• Air monitoring	• Baseline air study
	• Construction monitoring
	• Long-term monitoring

The schedule for completion of the installation of the facilities was 58 months from the entry of the consent decree. The long-term operation of the facilities and monitoring of the cleanup progress extends for up to 30 years.

EXECUTION STRATEGY

In the fourth quarter of 1988, prior to the entry of the SRC consent decree, a strategy for execution of the work was developed. Key objectives of the strategy focused on these areas:

- Aggressive project schedule

  The schedule in the consent decree specified 58 months to complete the installation of the facility. Intensive early planning was used to develop a detailed schedule and plan to meet and if possible, to beat the schedule. This effort was extremely important since calculations indicated that for every year in the delay of operation of the pump-treat system extended the pumping time by 7 years. In addition, once a project team is established, the on going fixed cost for a project is significant - time is money. An aggressive schedule was developed which, if accomplished, would complete the installation of the facilities as defined in the Remedial Action Program (RAP), in 28 months. Keys to the schedule logic were working the project elements in parallel rather than sequentially as defined in the RAP combined with programs aimed at expediting agency approval of project submittals.

- Avoid engineering interruptions

  To avoid additional cost and to improve engineering continuity on a project, it is advantageous to avoid changes in project personnel. The consent decree required the PRPs to submit the project documents in stages, and following approval, to proceed to the next phase. Following this approach would create situations whereby the engineering staff must be idled while waiting on comment/approval from the agencies. To avoid this interruption, the plan called for the design to proceed "at risk".

- Large Bid Packages

  In order to attract major national construction contractors, the plan called for creating large lump sum bid packages. The intent was to draw upon well resourced major firms for the work. Their approach would provide the flexibility to react to major changes in the work.

- Experienced Remedial Contractors

  The intent was to define and use only <u>experienced construction contractors</u> with remedial work experience. The desire was to select a firm responsible for construction which were, in fact, experienced constructors. Approximately 45 firms were screened to develop a final bid list of five firms for the major construction package.

- Meet/Beat Project Budget

  CERCLA projects are under time and performance pressures with cost being a secondary focus. In order to raise the level of importance of cost in the project team, budgets/cost tracking/cost emphasis programs were put in place.

- Shorten Communication Lines

  In order to expedite design approvals (within the design team and with the agencies) several programs were implemented. Included were:

  - PRP representative located in design contractor office.
  - Informal, intermediate design reviews with the agencies.
  - Weekly conference calls with all lead people.
  - Weekly contractor meetings in field.
  - Monthly senior management reviews in field.

- Solve the Problem

  The PRPs signed on to a consent decree intended to solve the environmental problem at the site. The team realized the potential for new data which could impact the scope of the work defined in the RAP. The team was charged with "solving the problem" even though the new data could require additional work or could result in elimination of or change in the scope specified in the RAP.

- Team Approach

  In order to develop a positive relationship among the parties involved in the work (PRPs, contractors, USEPA, IDEM, City of Seymour) aimed at solving the problem, the focus was on building a team to do the work as opposed to a rigid divisional approach. The theme was "Ours Is To Remediate - Not To Litigate".

PROJECT INTERFACES

The number of interfaces and approvals required for a remedial project under CERCLA is extensive. In the case of SRC the list includes the following:

- The Trustee
- USEPA
- Indiana Department of Environmental Management
- City of Seymour
- USEPA Consultants (3-5)
- Geraghty & Miller in Plainview, NY
- Geraghty & Miller in Tampa, FL
- Trustee's Law Firm in Indianapolis (Sommer & Barnard)
- Outside Laboratories (2-4)
- Engineering Consultants to Geraghty & Miller (3)

In addition to the review and approval of engineering design, there are three key documents utilized by USEPA and IDEM in approving <u>each segment of the work.</u>

- Workplans
- Health & Safety Plans (HASPs)
- Quality Assurance Project Plans (QAPPs)

Preparation of the documents, review by the agencies and their consultants, responses to agency comments, resubmission of documents, and ultimate approval was/is a lengthy, costly and frustrating process, and the individuals doing the work must understand and accept the process. Construction work cannot proceed until concurrence is obtained from the agencies.

COMMUNITY RELATIONS

Community relations for a remedial project is extremely important. A positive relationship can benefit the program. A negative relationship can have a detrimental effect on the work. In the case of Seymour, these relationships have been positive. Actions taken to assure this have been as follows:

- Early and frequent meetings with key community leadership
- Developed a rapport with local press
- Community presentations
- Newsletter
- Information pamphlet
- Exhibit
- Site spokesman

RESULTS TO DATE

The results to date for the Seymour program are:

- Facilities will be installed in 35 months versus the consent decree schedule of 58 months, in spite of numberous changes to the scope of work resulting from data developed during the RD/RA process.
- Cleanup objectives will be met
- No OSHA recordable injuries
- No adverse impact on public
- Positive community relations
- Cost will exceed budget
- Positive relations with agencies
- No stipulated penalties or fines imposed

LESSONS LEARNED

This project was approached as a normal process plant design with provision for the broad based team involvement and the public relations needs. Numerous lessons were learned which will be utilized on future CERCLA projects.

- Planning/Scheduling

  The time and effort devoted to the early strategy development was vital to the success of the project. Early planning permits the team to focus on alternative approaches which can improve the project. In addition, the team can have an opportunity to anticipate potential problems and prepare plans to react to the problems.

- Agency Approval Time

  The amount of time required to get thru the overall cycle of document preparation, agency comment, document modification, resubmission and ultimate approval far exceeded expectations. Most documents were submitted three times before approval was obtained. In order to stay on schedule, the PRPs proceeded at risk in numerous cases. This approach was successful. No problems (redesign, etc.) was required. Without the close team relationships among the parties this would not have occurred.

- Field Mobilization

  The plan called for mobilization of the field in the fall of 1989. In hindsight, the field was established prematurely. The time required to obtain approval of submittals delayed the start of field work.

- Design Data

  The data provided in the RI was not adequate for design. A complete set of current data was necessary to finalize design. The time required to obtain approvals for HASPs, QAPPs & Workplans to obtain the data was excessive and delayed the work. In the future, adequate time must be allowed for this data accumulation - or even better - complete information for design could be collected at the RI stage.

- Team Approach

  The team approach was successful. After a period of approximately 6 months, the team jelled and was a positive factor in reacting to project needs. This was particularly advantageous as new data dictated scope changes.

- Intermediate Design Reviews

  The intermediate design reviews were successful in expediting the final approval. The final design was submitted to the agencies for approval and placed for bid at the same time. With agency concurrence, the major construction contract was awarded less than three monthes later.

- Cost

  Cost results were disappointing. Several factors are worthy of comment:

  - Engineering cost was double the estimate. A lot of this overrun is attributed to the multiple submissions of packages to the agencies.

  - Laboratory costs far exceeded expectations.

  - EPA oversight costs are higher than expected.

  - Long term operating/monitoring costs were underestimated.

  - Changes to the scope of work were greater than anticipated.

- Community Relations

  The relationships in the community were a positive factor in the successful the of the work. Division of resources to handle problems in the community were not required.

Advances in Hazardous Waste Site Alluvial Sampling

(Author(s) and Address(es) at end of paper)

INTRODUCTION

Ground-water remediation at hazardous waste sites quite often fails to meet state and federal established goals. In a recent pump-and-treat study of 19 active systems, Haley et al. (1989) found that most systems had been operated longer than their initial projection for clean-up. Estimates could not be made as to the time remaining for ground water restoration. Inadequate design and failure to evaluate ground-water remedial actions stems from the inability to understand complex processes involved in the transport and transformation of contaminants in the subsurface environment. Paramount to this understanding is an adequate hydrologic, physical, chemical and biological characterization of the subsurface.

Conventional aquifer remediation systems are designed based on information gained from ground-water samples. This approach is flawed in many respects. For example, water samples alone provide little insight into mass transport limitations, native microbial ecology, geometric distribution of contaminants, or the partitioning of contaminants into liquid, solid or vapor phases (DiGiulio and Leach, 1990).

Conventional monitoring wells, when properly located and placed in sufficient numbers, can accurately define a ground-water plume but are inadequate in locating sorbed or entrained contaminants. This is because ground water collected from wells is usually from the more transmissive sands and gravels while contaminants are often associated with less conductive silts and clays. The long-term concentration of contaminants in more conductive strata is controlled by contaminant diffusion from fine-grained materials. Therefore, ground-water samples alone tend to underestimate the true contaminant mass.

Core samples are extremely useful in evaluating not only the geometry of the plume and less transmissive zones but also the sorption and desorption of contaminants from these zones. Cores can be collected and evaluated in the laboratory then the information can be used to complement remediation design.

When evaluating the feasibility of enhanced biological degradation for remediation of subsurface contaminants, the collection of aquifer core material is important for a number of reasons. Most subsurface bacteria are associated with solid phase material and cannot be characterized by ground-water samples alone. In addition, the use of microcosm studies to determine treatability parameters must be conducted using core material that represents aquifer conditions as accurately as possible. It is also important to describe the vertical distribution of contaminants so that injected water carrying oxygen and nutrients is efficiently utilized.

It has been speculated that as many as ninety percent of the hazardous waste sites are located in unconsolidated sediments and are contaminated to depths of less than one hundred feet. Therefore, hollow-stem auger drilling and coring are the logical choices for subsurface characterization in such geologic material.

An accurate definition of contaminant plume geometry, however, has remained a challenge for the engineer, especially in unconsolidated saturated zones where various solvents or hydrocarbon contaminants and their associated microflora exhibit concentration changes both laterally and vertically through time. Physical collection of samples for snapshot characterization with conventional hollow-stem auger equipment in heaving sediments has been virtually impossible. In hollow-stem auger drilling, when the inner string of tools is raised, artesian pressure forces cohesionless sand up the annulus of the auger, blocking the inner string of tools from reentering the auger. Once this occurs, conventional sampling can no longer be performed.

New hollow-stem auger drilling and sampling techniques and sample handling equipment have been developed to resolve these difficulties and are presented in the following discussion (Leach et al., 1988, 1989).

Cores are also required to assess the applicability of soil vacuum extraction for remediation. When most of the contaminant mass lies a few feet above and below the water table, as in underground petroleum tank leaks, it may be possible to lower the water table and apply vacuum extraction for remediation. This technique can often be faster and more economical than pump-and-treat remediation systems.

The selection of core sampling method is often based on time, cost, and availability of drilling equipment rather than the site's hydrogeologic conditions (Keely and Boateng, 1987a). Cores are greatly affected by the sampling method used; therefore, core sampling procedures should be dictated by the intended use of the core material. Once a core is removed from its subsurface environment, physical, chemical and biological changes immediately begin to occur. These include moisture loss, oxidation, gas exchange, and alteration to the biological community. Therefore, special care must be taken to minimize these disturbances. The cost of core collection should not play a major role in its use in designing a monitoring system. Often this preliminary phase of aquifer remediation is a small percentage of the total project cost and can be invaluable in assuring that the information collected leads to an efficient and lasting restoration of the site.

BACKGROUND

Since the 1950's, conventional hollow-stem auger coring has generally been accepted as the most efficient and reliable method of collecting unconsolidated in-situ soil samples for contaminant and microbial characterization of hazardous waste sites.

There have been a number of recent articles written on hollow-stem auger drilling procedures and their advantages in coring unconsolidated material (Perry and Hart, 1985, McRay 1986, Hackett 1987, Keely and Boateng 1987 a & b, Hackett 1988, and Leach et al. 1988). Soil sampling equipment developed by essentially all the major hollow-stem drill manufacturers perform extremely well, even below the water table

where the unconsolidated materials contain sufficient clay to maintain cohesive properties (Central Mine and Equipment Company, 1987; and Mobile Drilling Company, 1983).

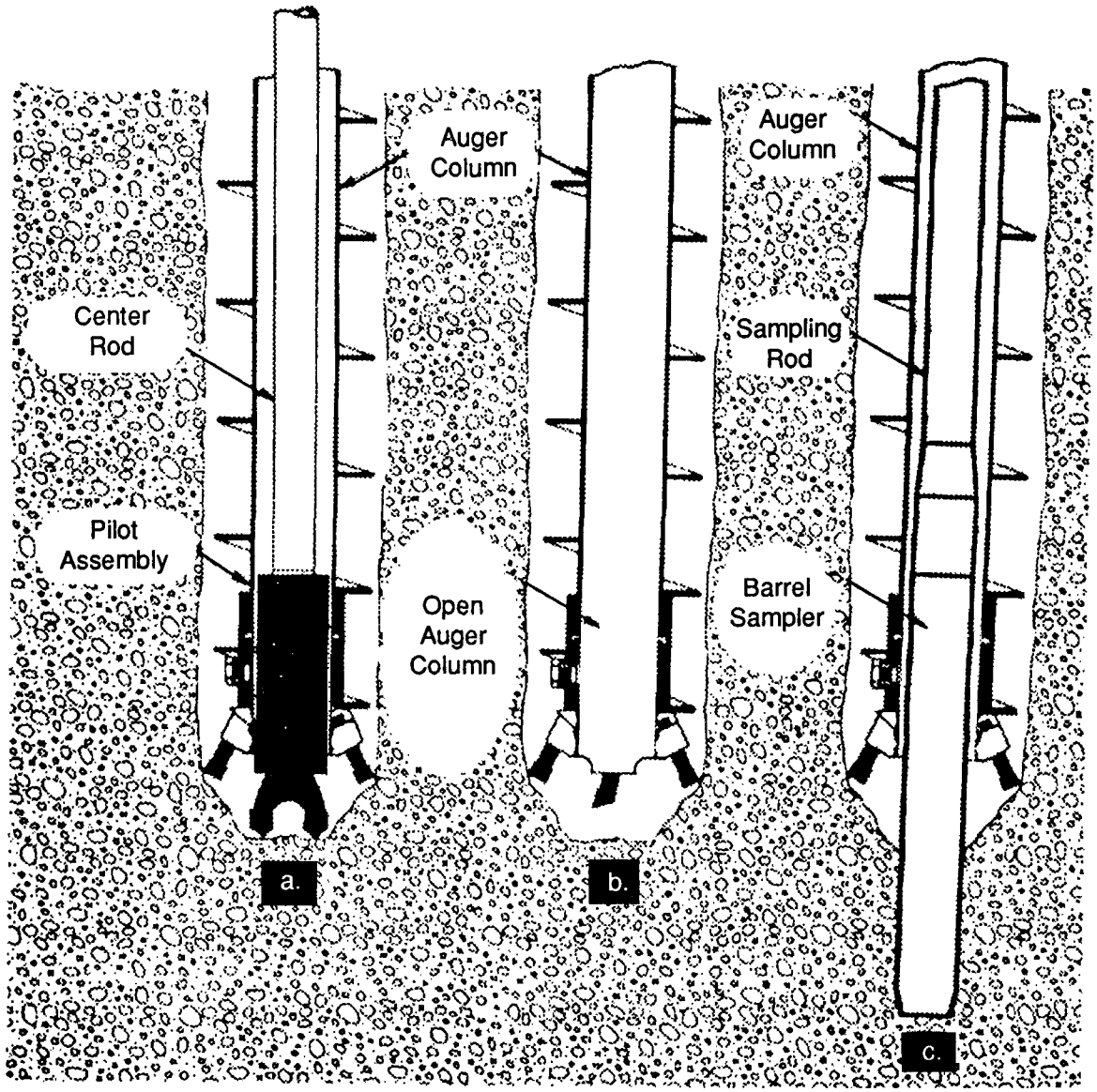
There are a number of distinct advantages of hollow-stem auger equipment over other conventional equipment used for drilling and sampling unconsolidated materials. Most important is that no drilling fluids are used in the drilling or sampling process during normal operations. Therefore, there are no interferences to samples or wells from introduced fluids. Second, no lubricants are used on tool joints or couplings, so organic materials are not introduced into the borehole during drilling.

Conventional hollow-stem auger soil sampling is performed by drilling to a desired sample depth with two strings of tools, a pilot inner string with a lead bit inside the hollow auger and the auger itself which has an outer bit and helical flighting to carry the cuttings to the surface (Figure 1). The inner pilot bit assembly can be removed when the desired depth is reached, leaving the hollow auger in the borehole to serve as a temporary casing. Sampling can then be easily done by inserting a split spoon or barrel sampler down the auger annulus and hydraulically pressing or driving the sampler to the desired sample depth or until it has filled (Riggs, 1983). If a deeper sample is desired, the inner pilot bit assembly can be inserted into the hollow auger and the borehole drilled to the next sampling depth.

An alternate method of hollow-stem auger coring can be performed by using an in-line bearing assembly on the drill spindle. This bearing allows the core sampler on the inner pilot assembly to remain stationary as the outer auger drills to the desired depth, minimizing sample disturbance (Figure 2). The core sampler is carried downward with the augers as the drill advances and samples are pared as they are pushed into the sampler. The advantage of this method of coring is that a continuous profile of core material can be collected by retrieving the sampler each time it fills and reinserting an empty sampler.

One disadvantage of this method is that if certain depths do not need to be sampled, the sampler must be capped and used as a plug for the auger annulus during drilling to a desired depth or the bearing assembly on the spindle must be removed and the borehole advanced with the inner pilot bit assembly. Drilling with a capped sampler will be slower than normal, especially in semi-consolidated sands and shales. However, removing the bearing assembly is even more time consuming.

The above procedures work extremely well in unconsolidated sediments in the unsaturated zone and in the saturated zone, as well, when enough clay is present that cohesive properties of the soil are retained and the borehole remains stable. However, numerous unsuccessful drilling techniques to capture totally cohesionless aquifer material below the water table have been tried. Such sediment conditions are routinely encountered in the saturated zone where artesian conditions exist. During hollow-stem auger drilling, when the inner string of tools is raised, artesian pressure can force cohesionless sand up into the annulus of the hollow auger (Figure 3). Once this occurs,



a. Hollow-stem auger with center head
b. Hollow-stem auger with center head removed
c. Hollow-stem auger with sampler inserted

Figure 1. Conventional Hollow-Stem Auger Drilling and Sampling (after Riggs, 1983).

conventional sampling methods can no longer be managed since the sediment materials have blocked the lower portion of the auger and sediments are too fluid to be retained in the sampler. During retrieval, core material will fall out of the sampler and sample depth integrity is destroyed by upward flow of sediments. This problem prompted systematic development of a series of innovative modifications of hollow-stem auger drilling and sampling techniques which allow sampling of fluidized sediments while controlling heaving without adding borehole fluids to control the hydraulic pressure head.

DISCUSSION

In order to solve the problem of capturing sediment samples in flowing sands with hollow-stem auger drilling techniques, modifications to the drilling equipment and conventional drilling procedures were required. The borehole had to be drilled in such a way so that when a desired sampling depth in flowing sands had been reached, the annulus of the auger would be open and free of heaving sand until an in situ sample could be collected. The obvious technique used by many drillers was to fill the annulus of the auger with either drilling mud or fresh water to control the hydraulic head once drilling proceeded below the water table. The inner pilot bit assembly could then be removed and the sample collected through the column of drilling fluid. This obviously is

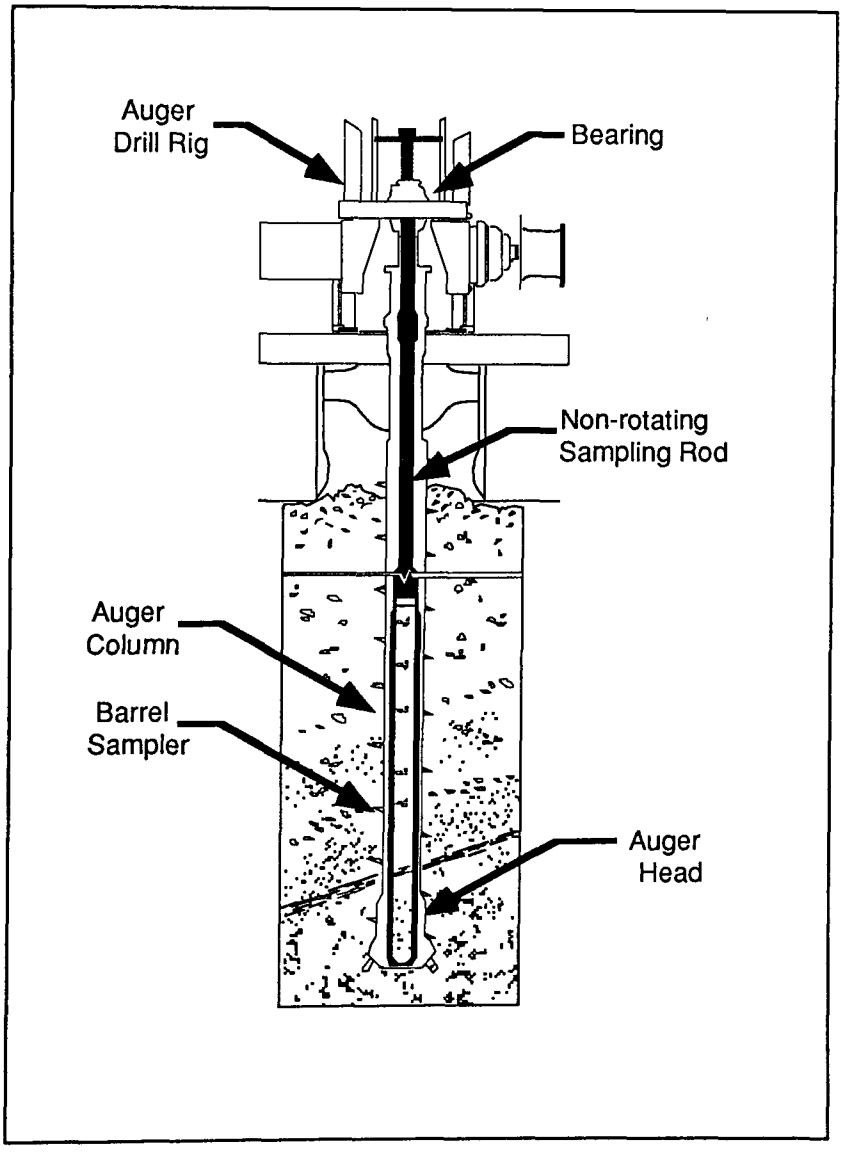


Figure 2. Conventional Continuous Hollow-Stem Auger Coring (after CME, 1987).

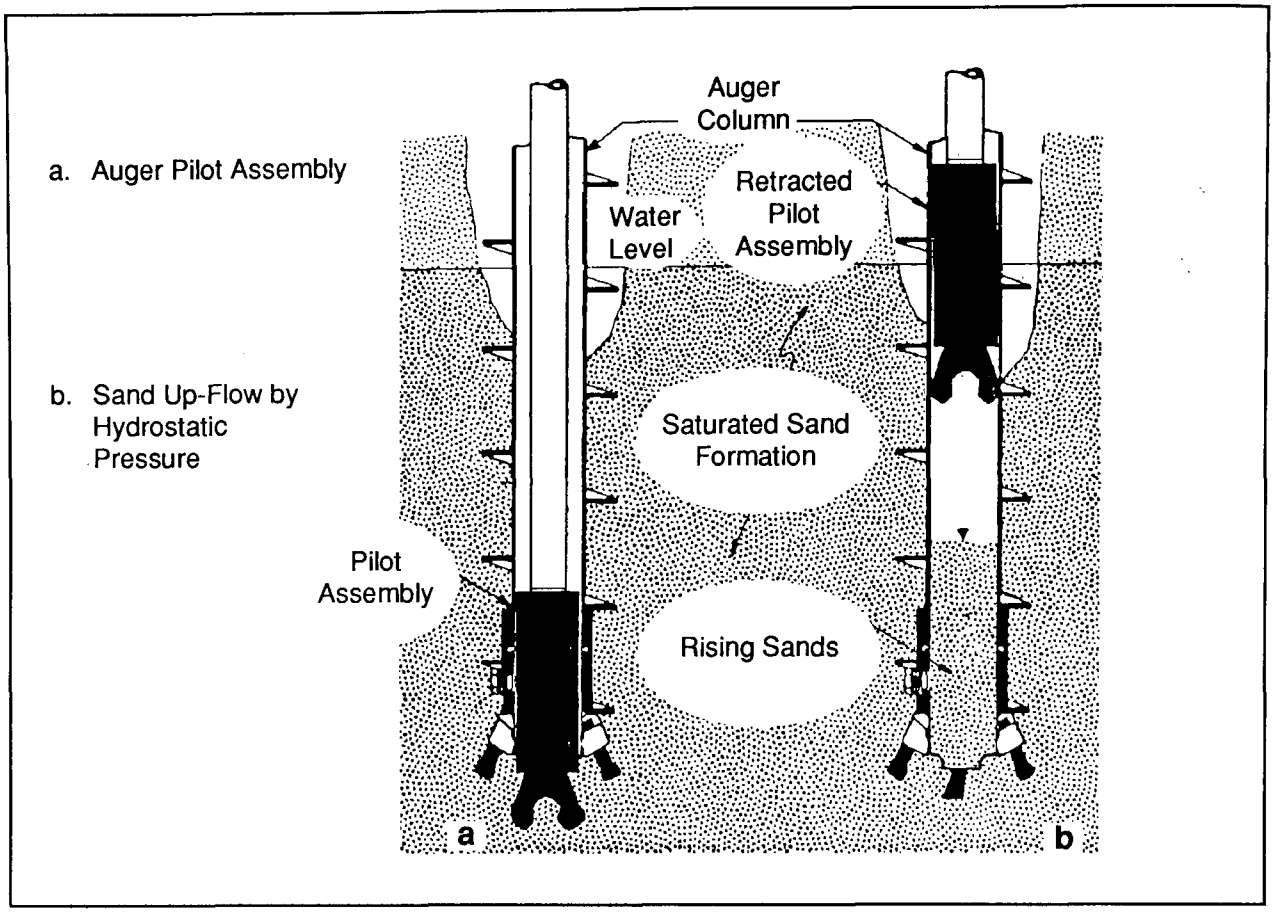


Figure 3. Hollow-Stem Auger Blocked with Heaving Sand (after Hackett, 1987).

a very undesirable method for core sampling hazardous waste sites since the organics in the drilling fluids can chemically react with the sample and destroy its integrity.

Several drillers have been successful collecting samples of flowing sands with hollow-stem auger equipment by blocking the annulus of the auger bit with a machine fitted non-retrievable knock-out plug (Perry and Hart, 1985). The borehole can be drilled with this fitted cap by maintaining constant vertical pressure and not using the inner pilot bit assembly. These plugs are normally made up of wood, metal or some synthetic material such as PVC. Stainless steel is probably the most common because of its strength and inertness.

Once the borehole has been advanced to the desired sample depth, the core sampler (split-spoon or barrel sampler) is carefully lowered inside the auger with the center rods until it rests on top of the knock-out plug. The drill spindle is then placed on top of the center rods to apply vertical pressure on the knock-out plug and to dislodge it as the augers are lifted about 12 to 18 inches. The augers are then fixed in this free hanging position to allow unrestricted access to the sample. The sample is then collected by reciprocally driving or hydraulically pushing the sampler downward with the center rods. Consistent sampling with this method is not routine because the knock-out

plug cannot be consistently dislodged into the side of the borehole. When this occurs, the knock-out plug continues to block the entry of sediment into the sampler as it is forced downward. Another objection to using knock-out plugs is that it is not retrieved and is left in the borehole to decompose with time. This foreign material could adversely affect monitoring wells or the integrity of cores taken at a future date.

Modified Auger Head

To resolve these problems, an innovative clam-shell cap has been developed to replace the knock-out plate or the use of drilling fluids (Figure 4). This cap can be used equally well for sampling in flowing sediments or well construction inside the hollow auger. The cap is mounted on a hinge which is welded to the auger head and is held closed by vertical pressure as the auger is axially rotated and vertically advanced

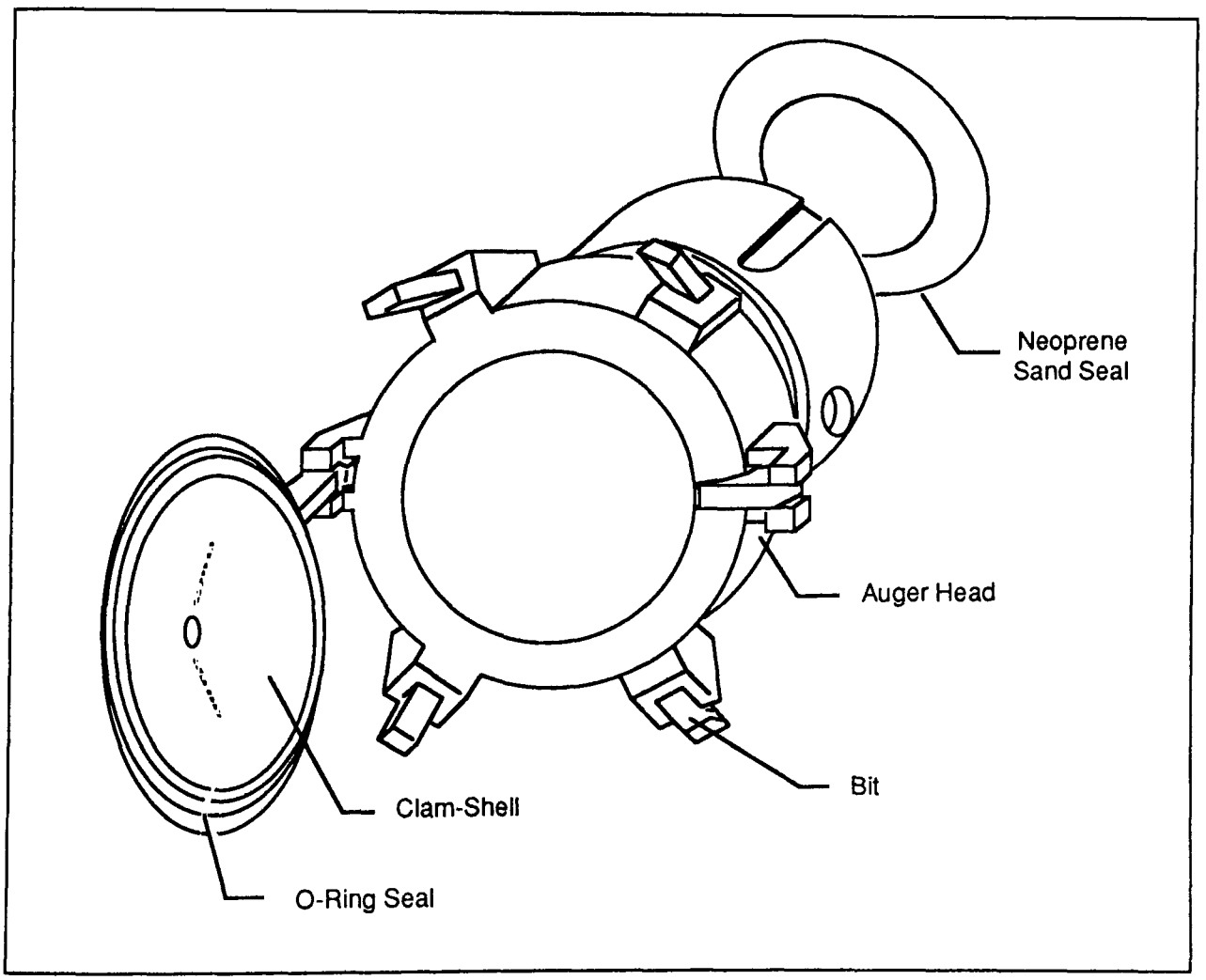


Figure 4. Clam-Shell Capped Auger Head with a Sand Seal

(Gillham et al., 1983). The original cap design contained two doors, each hinged on opposite sides of the bit which literally open like a clam-shell. These have been used very successfully for years and are still used by many drillers. However, when drilling to depths in excess of 20 feet below the water table, they tend to leak and occasionally sand may enter the auger and block the entry of the sampler. To remedy this problem, the cap was redesigned in 1989 to contain a single door with a recessed face and an o-ring seal around the shoulder of the recessed area. The door is now water tight and samples of flowing sediments have been routinely collected at depths of 70 feet, 40 feet below the water table.

An additional feature was added to the auger drilling tools to control flowing sand during 1990. During deep sampling, in excess of 30 feet below the water table, there is often high hydraulic pressure when the clam-shell door is opened with the sampler. When this pressure exists in fine sands, the sands occasionally flow between the outer wall of the sampler and the inner wall of the auger. As the hydraulic head stabilizes, the sands settle and form a pack on top of the sample tube, thus blocking it in place and preventing its retrieval.

To overcome this problem a special neoprene sand seal was installed in the joint between the top of the auger head and the bottom of the lead auger (Figure 4). This seal is held in place by compression of the outer edge of the seal between the top of the auger head and an internal shoulder inside the auger tube. Therefore, it is located about 6 inches above the inner face of the clam-shell door. The seal contains a hole in the center which is slightly smaller than the outside diameter of the sampler tube, forming a tight friction seal as the sampler is pushed through to open the clam-shell door. This sand seal is extremely effective in preventing sand movement inside the auger column during sampling.

As presently designed, it is not possible to re-close the clam-shell door on the lead auger and continue drilling to the next sample depth once it has been opened, nor is it desirable since contaminated soils generally enter the auger annulus when the sampler is retrieved above the internal sand seal. Therefore, if deeper samples are desired, the entire flight of augers must be carefully removed from the borehole without rotation. The annulus of the augers, exterior flighting clam-door and all components of the piston sampler must be thoroughly high pressure steam cleaned to insure integrity of sequential samples. The borehole can then be refilled with clean washed sand or uncontaminated cuttings and redrilled to the next desired sample depth. In many situations, researchers prefer to move the rig a few feet and drill a new hole to the next sample depth to insure sample integrity. Admittedly, the process is slow, but the tools must be clean and the clam-shell door properly re-closed if high quality sampling is to be consistently obtainable.

Piston Sampler and Modifications

The single clam-shell door and seals that were added to auger head are extremely effective in holding cohesionless sediments in place until samples can be collected. However, as noted earlier, conventional samplers, such as the split-spoon

and barrel samplers are generally ineffective in flowing sediments. Samples are so slurried in non-cohesive sands that the cored sample falls out during retrieval due to the force of gravity.

This problem was partially solved when the Institute of Water Research, University of Waterloo, Ontario, Canada, developed their special wireline piston sampler (Zapico, et al., 1987). This sampler utilized a special piston inside an aluminum sleeve which is inserted into a five-foot long core barrel. Once the sample is collected, the sleeve can be removed from the core barrel after it has been raised to the surface. The internal piston is attached to a wireline which is tautly fixed to something immovable at the surface, usually the rig, after the sampler has been positioned at the bottom of the borehole ready for sampling. Sampling is done by driving the sampler downward by reciprocal pounding on the protruding end of the center rod at the surface. As the sampler is driven, the wireline holds the piston in its initial position creating a vacuum on the sample as it is collected. This vacuum is maintained on the sample during retrieval, enhancing its recovery to the surface. The Waterloo sampler is also equipped with a left hand threaded drive head so that the center rod can be decoupled from the sampler before it is extracted from the sediments. The string of center rods is retrieved once they are decoupled. The sampler is then retrieved using the wireline connected to the piston. The Waterloo designers contend this retrieving technique will minimize sample loss caused by the delay and vibrations that accompany center rod hoisting and disconnection. Extensive field testing of the original Waterloo wireline piston sampler in extremely fluid non-cohesive sands revealed problems of consistent sample recovery. Sample material could not be consistently retained during retrieval, even under partial vacuum with the piston; thus improved methods of sample collection were sought.

Several modifications of Waterloo's piston sampler design were made while keeping their basic design principle of vacuum piston sampling. The aluminum sleeve-cannister used by Waterloo was discarded in initial sampler design modifications; since samples are normally to be analyzed in the field or in research studies, they are aseptically collected and preserved in the field. However, the sleeve design has been used in several special research studies where intact cores were required for special laboratory microcosm studies. Special modifications of the sleeve design are discussed later.

The authors' modifications of the basic Waterloo piston sampler are shown in Figure 5. A standard Central Mine and Equipment Company (CME) four-inch I.D. by five foot long standard thin walled barrel sampler was adapted to receive a wireline activated piston with many similarities in design to that of Waterloo's. The components of the piston include four pairs of neoprene seals separated by five brass spacers with the end of the bottom brass spacer capped with two teflon wiper discs and a stainless steel plate. The bottom brass spacer contains 8 x 1/4 inch Allen screws to adjust the compression of the neoprene seals against the inner walls of the CME sample tube. The top of the piston contains a swivel nut attached to the wireline which prevents twisting the wireline during assembly and disassembly. The primary difference in

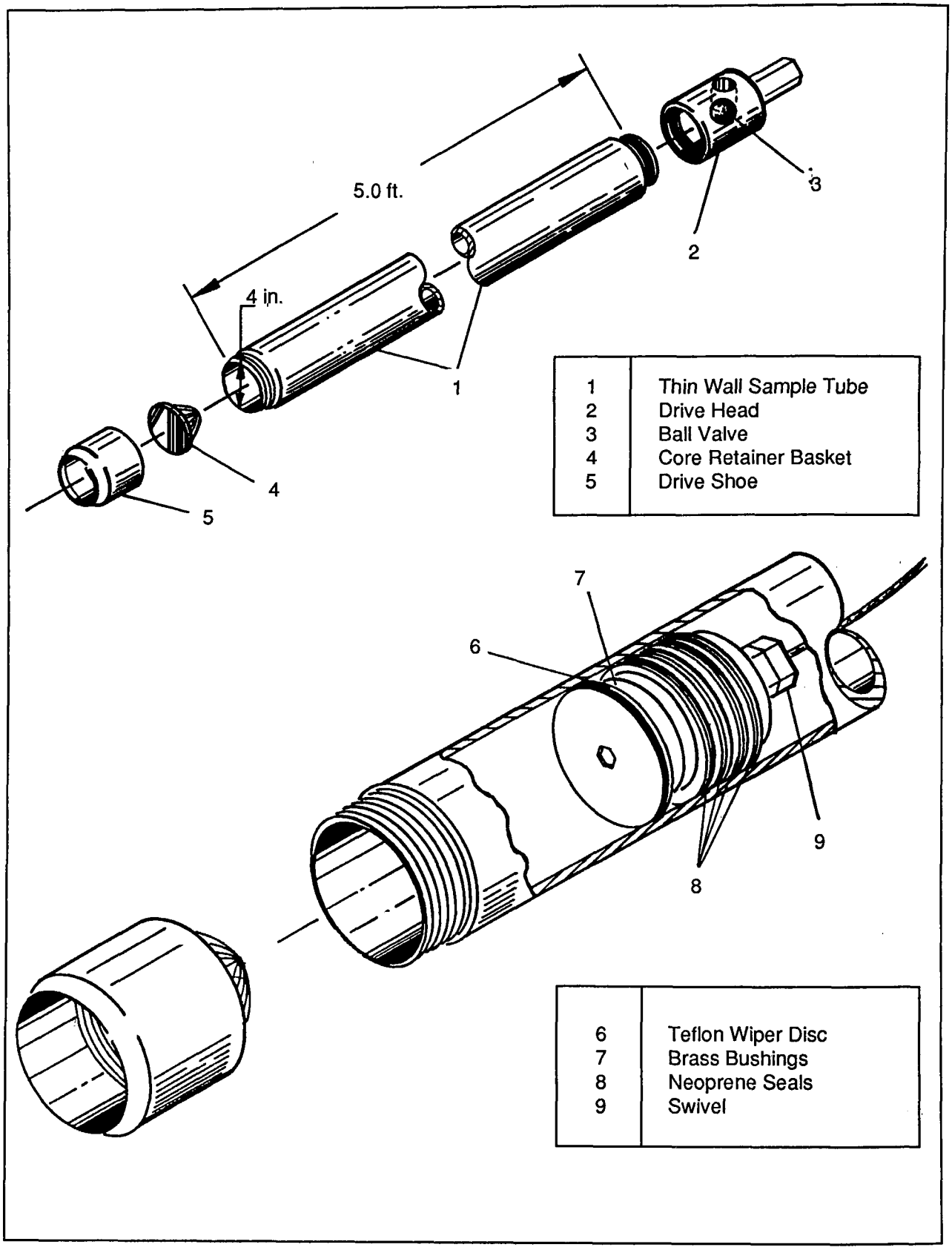


Figure 5. Wireline Piston Sampler

Waterloo's piston design and the improved design is that the number of neoprene seals was doubled for better sealing capability; two additional Allen screws were added for more uniform compression adjustment; and teflon and stainless steel wiper discs were added to prevent contamination of core samples from the neoprene seals. Two additional features include a pressure relief ball valve in the drive head and a special strong retracting core retainer basket. Waterloo's sampler contained neither the pressure relief valve nor the core retainer basket. The ball valve enhances core recovery by reducing the shock created by compressing internal gases and fluids between the piston and the drive head inside the sample barrel.

The addition of a strong retracting core catcher basket has also improved core recovery by creating an additional core trapping capability. Core recovery has been consistently above 90 percent with the added design features.

The modified wireline piston sampling procedure is used in combination with the clam-shell auger head with a neoprene sand seal. It is inserted into the empty auger tube after drilling to the desired sample depth with the clam-shell auger. The sampler is slowly lowered with the center rods while maintaining only hand tension on the wireline until it passes through the annulus of the sand seal and makes contact with the inner face of the clam-shell door, thus preventing piston movement. The door is opened as described earlier by maintaining vertical pressure on the center rods as the auger column is lifted and caught with an auger fork. This procedure allows the sampler to make immediate contact with the non-cohesive sediments without sediment disturbance by hydraulic movement. The wireline is then pulled taut and fixed rigid before the sampler is hydraulically driven or pushed into the sediments. The sampler is retrieved with the center rods instead of the wireline as described by Waterloo. The authors' prefer sampler retrieval using the rods while maintaining hand tension on the wireline insuring a greater margin of safety should the sampler become stuck in the auger. If a center rod pin should sheer or fall out, the driller would have the additional safety of the wireline. In addition, if the sampler is retrieved by the wireline and the piston slips, unwanted sample could be pulled into the sampler, or if the piston slips while the sampler is in the water or air column above the sample depth inside the auger, these fluids could be drawn into the collected sample, grossly affecting its integrity.

Once the sampler has been removed from the augers at the surface, the bottom of the sampler should be immediately sealed by placing it in a plastic bag and taping the top of the bag around the sampler cutting shoe, making it air tight. This minimizes oxidation of the sample and helps preserve sample integrity for chemical and biological analysis. The sampler should be held in its vertically retrieved position to preserve the sample's structural integrity during sampler disassembly. Once the sampler drive head has been removed, the piston can be withdrawn from the top of the sampler by pulling the attached wireline while holding the sampler stationary. A fitted stainless steel or teflon plug should then be immediately pushed down the inside of the sampler barrel until it is in contact with the top of the sample. This minimizes aeration of the top of the sample and traps the sample so its structure is maintained. The sampler tube can then

be placed horizontally in a hydraulic extruder assembly and pressed out by pushing on the teflon or stainless steel plug. Before hydraulic pressure is applied, the bagged drive shoe core and retainer basket should be removed. Samples can then be collected directly from the sample tube as they are extruded. Since the core generally has its outer surface contaminated with oxidized material from the inner walls of the core barrel, the wall material can be peeled away with a stainless steel paring device attached to the end of the sample barrel (Figure 6). These procedures allow collection of totally cohesionless materials in their native subsurface structural position.

Sleeve-Piston Sampler Modifications

In research and remediation studies, it is often necessary to collect intact cores in the field and transport them to the laboratory for detailed analysis and experimentation. To satisfy this requirement, a number of modifications to the Waterloo sleeve piston sampler design was performed (Figure 7). Waterloo's sampler, as discussed earlier, contains a removable aluminum sleeve which extends through the entire length of the sampler tube with an internal piston used to hold a vacuum on the sample. The authors were tasked to design a sampler with a 36-inch stainless steel sleeve that could be easily separated in six-inch sections in the laboratory for analysis of vertical distribution of contaminants. Each section was also fitted with temporary plugged ports which could be plumbed with mininert valves in the laboratory for gas chromatographic analysis of the time series degradation of hydrocarbon products.

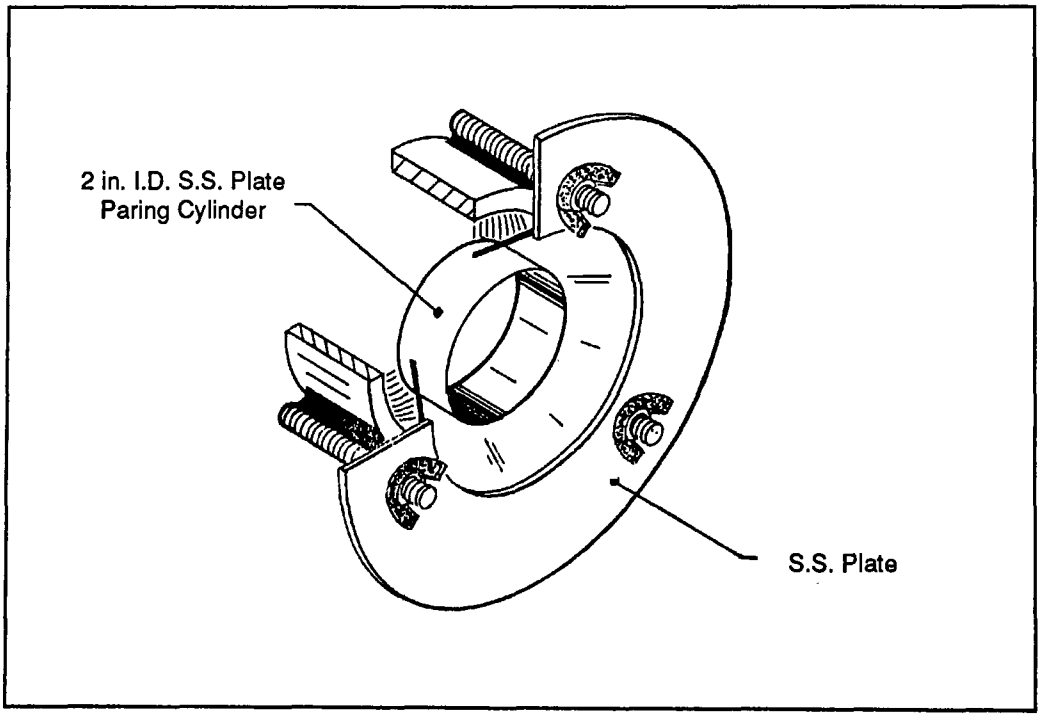
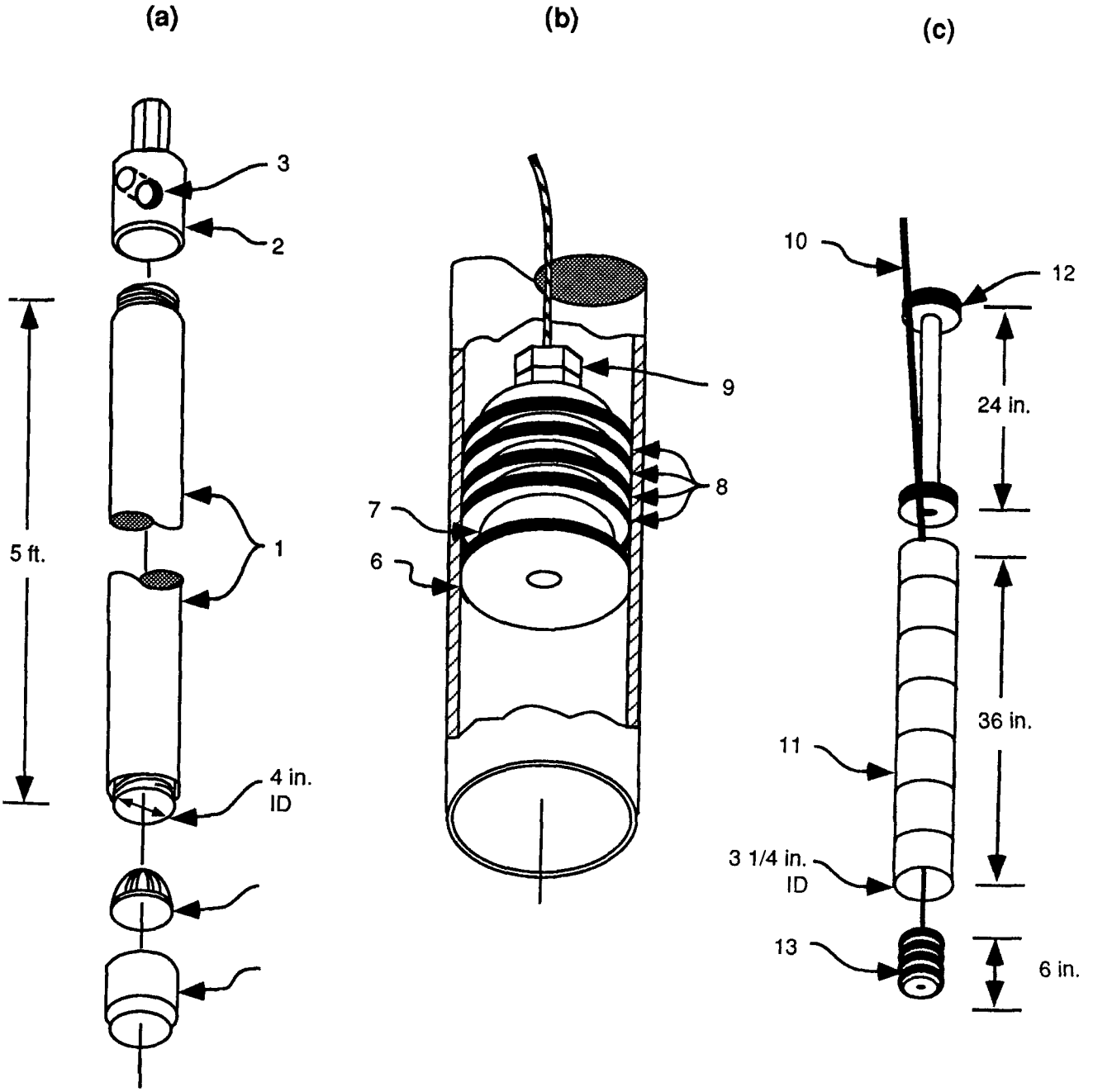


Figure 6. Core Paring Tool.



1.	CME Barrel Sampler	8.	Neoprene Seals
2.	Drive Head	9.	Swivel
3.	Ball Valve	10.	Wireline
4.	Core Retainer Basket	11.	Core Sleeve
5.	Cutting Shoe	12.	Steel Bar
6.	Teflon Wiper Disk	13.	Piston
7.	Brass Bushing		

Figure 7. Modified Sleeve Piston Sampler

The standard 4.00 inch I.D. by 5.0 foot CME sampler was modified to accept a stainless steel sleeve in this design. Stainless steel sleeves were used because of their inert properties. A prescored 3.25 inch O.D. by 3.00 inch I.D. by 36 inch long stainless steel sleeve was fitted inside the standard CME sampler and held in position to receive the sample by a tightly fitted steel bar located in the top half of the sampler tube. Since noncohesive flowing sediment samples were routinely required, the sleeve was fitted with a smaller designed version of the wireline piston. The CME barrel sampler tube was cut at mid-section and fitted with a collar for easy disassembly and removal of the stainless steel sleeve. In addition, the core retainer basket was modified so its spring steel fingers would fit inside the bottom of the stainless steel sleeve.

Sampling is performed in the same manner as described earlier with the authors' modified piston sampler. Once the sampler has been retrieved to the surface, the drive head can be removed and the steel holding bar removed from the top of the CME barrel sampler by pulling the piston out of the top of the sleeve. The piston can then be removed along with the top half of the CME barrel sampler, exposing the top of the stainless steel sample filled sleeve. Before removal of the sleeve, the top is packed with sterile paper and covered with hot wax to prevent movement of the sample inside the sleeve and minimize exposure to atmosphere. The sleeve can then be vertically lifted out of the bottom half of the CME sampler, inverted and sealed with sterile paper and wax as described above. The sleeves are then normally packed in ice and transported to the laboratory in their natural vertical position to minimize separation of the core.

This sampling technique allows a thorough evaluation of aquifer heterogeneity and its impact on treatability of contaminants, even in cohesionless sediments that previously could not be sampled without disturbance of the stratigraphic distribution.

Aseptic Glove Box Sampling

Site characterization of the subsurface distribution of oily phase hydrocarbons or volatile organics and associated microflora in sediments requires a special aseptic and oxygen free environment for capturing the samples as they are extruded out of the sampler tube (Wilson et al., 1989 and Armstrong et al., 1988). When samples are extruded from a sampler barrel in the natural atmospheric environment, unstable organics instantly volatilize and the sample absorbs oxygen, destroying its chemical and biological in situ integrity. Preserving the native sample conditions can be achieved by extruding and collecting the sample inside a specially designed field glove box containing an inert atmosphere (Figure 8). The sealed cutting shoe end of sampler barrel, as described earlier, can be inserted into a specially constructed portable 1/2 inch thick plexiglass glove box with dimensions of 2 x 3 x 4 feet. The box is constructed with a special self-closing iris diaphragm for inserting and sealing the sampler barrel. The glove box can be prepared for sample collection in approximately 30 minutes by filling it with presterilized sample containers and sterile stainless steel core paring devices and purging it with nitrogen gas to reduce the internal oxygen level below detectable limits.

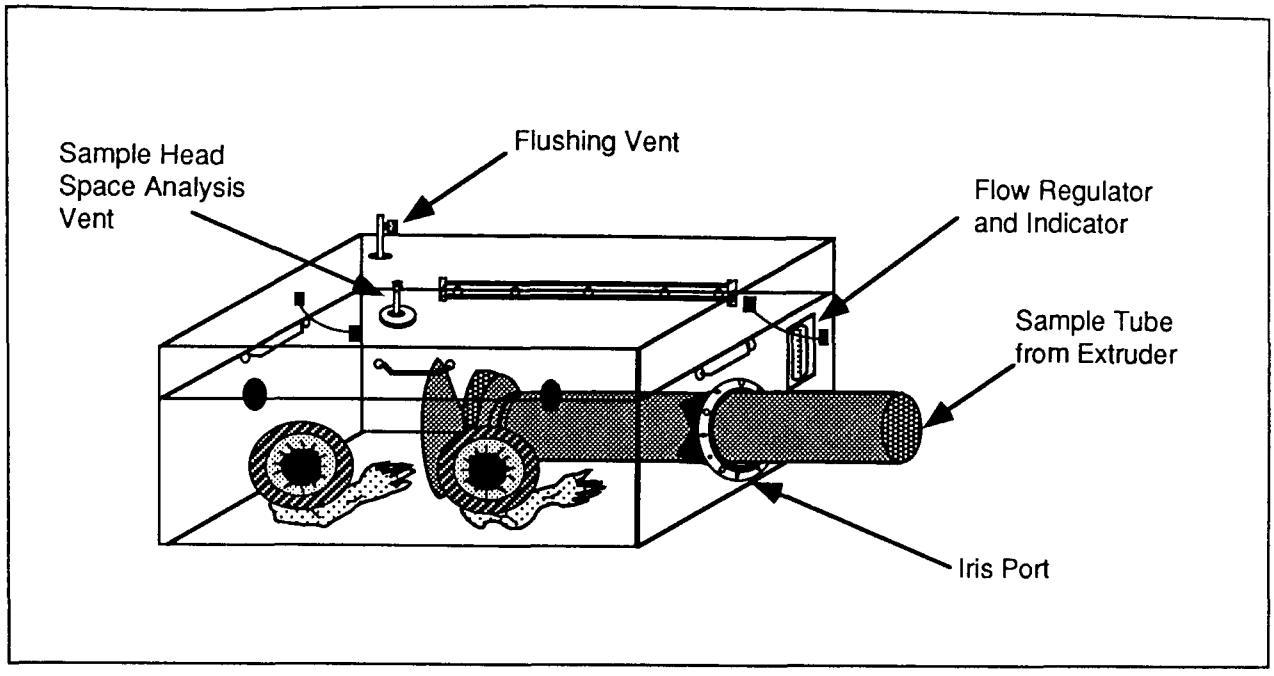


Figure 8. Field Sampling Glove Box.

Quality assurance tests of the field glove box were conducted by measuring a series of 1,000 microliter samples of vented gas with a Varian Model 90-P gas chromatograph equipped with a thermal conductivity detector. These tests verified that the air-oxygen level inside the box after 30 minutes' purging with nitrogen is consistently less than 0.02 percent on a volume per volume basis.

In preparation for field sampling, a sufficient number of sample containers were sterilized in the laboratory and packed for the entire site investigation program. Sterilization is done by thoroughly washing the containers and sealable lids then autoclaving at a temperature of 120°C at 1 atmosphere of pressure for 60 minutes. As the open containers and lids are removed from the autoclave, they are transferred to a laboratory environmental chamber or glove box. The chamber is sealed and the interior air is flushed from the box by purging with pressurized nitrogen gas for 30 minutes using a flow rate of 2500 L/hr at pressure slightly in excess of atmospheric. This procedure displaces gases inside the sample containers with nitrogen. After 30 minutes' purging the lids are wrapped in aluminum foil then screwed hand-tight onto the sample containers. The chamber is then opened and the sealed containers are removed and packed for transport to the field.

At the sampling site, a field glove box is filled with a sufficient number of presterilized sample containers and sterile, aluminum foil wrapped stainless steel core paring devices to collect a minimum of nine feet of cored sample (three separate barrels, each containing three feet of sample). Only three feet of sample is collected in a five foot sampler because of hydraulic pressure limitations of the extruding equipment when pressing out wet cohesionless sands.

About ten minutes prior to filling the glove box with sample containers, at least three paring devices are rinsed in 95 percent ethanol bath, placed in a stainless steel pan and ignited to fire-burn dry the excess ethanol. They are carefully wrapped in sterile aluminium foil and placed in the glove box. The box is then closed and purged with pressured nitrogen gas as previously described for laboratory procedures, reducing oxygen levels below detectable limits in 30 minutes. A positive pressure of nitrogen flow through the box is maintained during all sampling activities.

After horizontally mounting the sampler barrel in the hydraulic extruder assembly, the bag sealed cutting shoe is loosened to hand-tight. The glove box can then be slid onto the sampler barrel by inserting the bagged cutting shoe through the iris diaphragm. The cutting shoe and core catcher basket are removed and a sterile foil-wrapped paring tool and holding bracket are unwrapped and screwed onto the sampler barrel. About 2.5 inches' soil should then be extruded through the 2.5 inch diameter paring tool and broken away to expose an aseptic face on the core. Cores are then routinely collected, sealed and numbered inside the glove box. Between each three-foot sampling event the box can be removed from the sampler barrel and samples exited from the box through the iris diaphragm, placed in an ice chest and covered with ice for preservation and transport to the laboratory.

Once three three-foot samples have been collected and preserved, the box must be opened, thoroughly cleaned and prepared for repurging. If noninterrupted sampling is desired, a second glove box can be purged and made ready for additional sampling.

Additional innovative sampling activities can be performed inside the glove box for detailed site characterization or research activities. Often small duplicate subsamples are desired for quality assurance and very precise analysis of petroleum hydrocarbons. Small 25 ml sterile disposable syringes approximately 0.4 inches in diameter can be inserted directly into the core through the paring ring while pulling a vacuum as the sample is retrieved. The subsample can then be placed in 40 ml sterile VOA bottles containing 5 ml of <pH 2 water to preserve the sample. Pairs of miniature cores of each sample interval are normally taken for quality assurance documentation. This method fixes core material for later analysis without refrigeration.

The glove box is also equipped with special sample container lids with capped vents plumbed through the top of the box. This allows a quick analysis of the head space over volatile hydrocarbon samples using a portable combustible hydrocarbon analyzer meter (Kampbell et al., 1990). Careful sampling and portable analysis with the meter can detect the upper and lower interface of vapors in a hydrocarbon plume within a two-inch core section. The meter sensitivity allows measurement of concentration changes to within 10 meter units with an upper limit of 10,000 units. The equipment and procedures are extremely useful in site characterization. Incremental depth analysis of core headspace from a sufficient number of spatially located boreholes can accurately define the geometry, location and three-dimensional concentration gradients of hydrocarbon plumes. This procedure can be used to

determine the selective sampling depth for a number of boreholes and for selecting the proper screen intervals for monitoring wells. The procedure works equally well in identifying the vapor gradient in the unsaturated capillary fringe and the lower interface in the saturated zone.

CONCLUSIONS

Ground-water remediation at hazardous waste sites often fails to meet established goals because remediation design was based on inadequately characterized matrices and the processes involved in remediation were not well understood. Traditional designs of monitoring and aquifer restoration systems are based on the results of water samples alone. Such information is fundamentally inadequate in describing mass transport limitations, the indigenous microbial ecology and the dimensional as well as the partitioned distribution of contaminants. In order to obtain the type of information required to properly characterize a site for design of a remediation system and track its effectiveness, it is necessary to collect subsurface sediment samples. This can be extremely difficult, especially in cohesionless heaving sediments. It is of paramount importance that sampling procedures assure that chemical and biological integrity of the samples is maintained and that the information they provide accurately describes conditions at the site.

Conventional hollow-stem auger drilling offers one of the best methods of collecting unconsolidated sediment samples at contaminated sites. This coring method works extremely well, even below the water table, as long as the sediments have sufficient cohesive properties to remain stable. However, problems are often encountered in cohesionless material particularly below the water table and collecting samples from flowing sands has been virtually impossible.

These problems have been all but eliminated with the development of the clam-shell capped auger fitted with an internal sand seal and the wireline piston sampler. With the clam-shell capped bit, boreholes can be augered into cohesionless sediments to desired sample depths and held stable until the piston sampler is inserted through the sand seal and into underlying sediments, even when high artesian pressure is encountered. The vacuum created by the wireline piston in conjunction with soil entrapment by the core retainer basket allows more than 90 percent recovery of cohesionless samples, even to depths of 40 feet below the water table.

Refinement of the design of Waterloo's sleeve-piston sampler allows samples to be collected in prescored ported sleeves for efficient assembly of columns for research and treatability studies, greatly enhancing remediation design. The sleeves can be quickly sectioned and plumbed with mininert valves for laboratory tests of volatile organics, hydrocarbon degradation products and microcosm assessment.

The development of aseptic sample handling techniques in a field glove box containing an oxygen-free environment has revolutionized the capability for precise

quantitative and qualitative chemical and biological analysis of subsurface materials. Subsurface in situ conditions of cored sediments can be maintained during sample collection except for pressure, temperature and light. These procedures have significantly advanced the bioremediation design and assessment capabilities.

The glove box has an additional utility with the field capability of head space measurement of volatile organics with field monitoring equipment. This technology can save expensive drilling time in site characterization of contaminant plumes. The technology can also be used for precise depth location for screened intervals during monitoring well construction.

DISCLAIMER

This paper has not been subjected to Agency review and therefore does not necessarily reflect the view of the U.S. Environmental Protection Agency.

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